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From: Chief, Naval Technical Mission to Japan.
To : Chief of Naval Operations.

Subject: Target Report - Japanese Torpedoes and Tubes, Article 2 -
Aircraft Torpedoes.

Reference: (a) "Intelligence Targets Japan" (DNI) of 4 Sept. 1945.

1. Subject report, dealing with Target O-01 of Fascicle O-1
of reference (a), is submitted herewith.

2. The investigation of the target and the target report
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JAPANESE TORPEDOES AND TUBES
ARTICLE 2
AIRCRAFT TORPEDOES

"INTELLIGENCE TARGETS JAPAN" (DNI) OF 4 SEPT. 1945
FASCICLE O-1, TARGET O-01

MARCH 1946

U.S. NAVAL TECHNICAL MISSION TO JAPAN

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SUMMARY

ORDNANCE TARGETS

JAPANESE TORPEDOES AND TUBES
ARTICLE 2 - AIRCRAFT TORPEDOES

All research on aircraft torpedoes was conducted at the First Naval Technical Arsenal, KANAZAWA, Japan. The main plant concerned with production was the Kure Naval Arsenal.

There were no remarkable features about the aircraft torpedoes in operational use during the war, with the exception of the anti-roll stabilizers. The Japanese considered this innovation of great importance in improving torpedo performance.

Wooden tail frames, similar to those used on U.S. aircraft torpedoes, were used for air stabilization.

The launching speeds and altitudes varied from 100 to 250 knots and from 50 to 1000 feet.

Type 91, Modifications 1 to 7, carrying explosive charges of 330 to 925 pounds, were used throughout the war, but an improved Type 4 aircraft torpedo was introduced in 1944. All torpedoes had a speed of 42 knots with ranges of 1600 to 2200 yards.

The Japanese experimented with rocket and jet-propelled torpedoes, but without success. Many experiments were made with gliding torpedo bombs and with anti-submarine circling torpedoes with a moderate degree of success, but none was used in service.

In 1934 the Type 94 oxygen aircraft torpedo was developed, but the use of oxygen was troublesome and dangerous, and there was no need for long range, so it was abandoned soon afterwards.

The Japanese considered their aircraft torpedoes very dependable. The chief difficulty was in mass production, which was never really attained.

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REFERENCES

Location of Target:

First Naval Technical Arsenal, KANAZAWA, Japan.

Japanese Personnel Who Assisted in Gathering Documents:

Technical Comdr. K. FUKUBA, Aerial Torpedo Section, First Naval Technical Arsenal.

Japanese Personnel Interviewed:

Technical Rear Admiral S. NARUSE, in charge of the Aerial Torpedo Section, First Naval Technical Arsenal. (Active in torpedo design and development since 1919; studied Whitehead Torpedoes in England, 1927-28.)

Technical Rear Admiral S. OYAGI, Technical Research Bureau, TOKYO. (Actively engaged in torpedo research and development since 1919; studied torpedoes in England, 1927-28.)

Technical Commander K. FUKUBA, chief torpedo designer at the First Naval Technical Arsenal. (Twelve years experience in torpedo design.)

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INTRODUCTION

Information for this report was obtained in a series of interviews with responsible personnel connected with the development of aircraft torpedoes. The report presents as much data as could be obtained about aircraft torpedoes which were in operational use, and those in the experimental stages. The report as a whole endeavors to show the path along which Japanese aircraft torpedo development was progressing. It is to be noted that this report covers only aircraft torpedoes, information on other types being contained in NavTechJap Report, "Japanese Torpedoes and Tubes, Article 1, Ship and Kaiten Torpedoes", Index No. O-01-1.

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THE REPORT

Part I

GENERAL INFORMATION ON JAPANESE AIRCRAFT TORPEDOES

The First Naval Technical Arsenal near YOKOSUKA, Japan was the only research establishment concerned with aircraft torpedoes. Specifications for new designs (speed, range, weight of explosive, etc.) were supplied by the Naval Ministry, Aircraft Technical Division in TOKYO. Kure Naval Arsenal was the main plant concerned with production, but lesser plants manufacturing different components of the torpedo were located all over Japan. Enclosure (A) lists the production and cost figures for all aircraft torpedoes from 1931 to 1945.

The sea acceptance tests were made on the SHARU SHIMA range just off YOKOSUKA. All the torpedoes were fired from a rack, which was lowered into the water, and run down the range under small barges which were anchored at intervals. No hydrophones were used on the range. The speed was measured by timing the first bubbles to appear on the surface at the starting point and at each test barge along the range. The recorder in the exercise head also registered the torpedo's speed as the difference between the velocity head and the static head. Depth was measured by recorder only. No nets were used on the range. All exercise heads and recorders are discussed in detail in NavTechJap Report, "Japanese Torpedoes and Tubes, Article 1 - Ship and Kaiten Torpedoes", Index No. O-01-1.

Japanese aircraft torpedoes were not designed to meet requirements of specific airplanes but instead, the aircraft were modified to suit the torpedo.

The maximum and minimum altitudes for dropping torpedoes were approximately 1000 feet and 50 feet. All the latest type torpedoes were designed for a water-entry speed of 400 knots. Depth of dive was never specified, but in practice, shallow water shooting in a depth of 40 feet was satisfactory. For shallow initial dives an altitude of 100 feet, with an air speed of 140 knots, was used most often. The wooden tail frames used for air stabilization are described in Part II of this report. The maximum conditions under which a torpedo could be launched without structural failure, were 1000 feet at 250 knots, but the Japanese considered 330 feet and 180 knots as the best combination for a desired entry angle of 17-20°.

To prevent damage to the warhead on impact with the water, a rubber sheath, approximately 0.4 inches thick, was used to cover about 24 inches of the nose of the torpedo. This cover would shatter into small fragments when it hit the water.

A length to diameter ratio of 11 or 12 was found by the Japanese to be most satisfactory. They considered the U.S. aircraft torpedoes too short for a good underwater trajectory.

Rear Admiral NARUSE stated that many U.S. Mark 13 type torpedoes were sent to the First Naval Technical Arsenal for study. Some of them were equipped with shroud rings but he did not know where, or under what circumstances they were recovered. He claimed to have tried the shroud ring on Japanese aircraft torpedoes about ten years ago, but didn't like it because of the increased resistance, and interference with the propellers.

Model experiments were carried out at the First Naval Technical Arsenal in a large water tunnel, and with a catapult and water tank. These are discussed

in NavTechJap Report, "Japanese Ordnance Research, Article 3 - Torpedo Models", Index No. O-39-3.

Eight tail fins were tried on some of the Type 91 torpedoes, but experiments showed that recovery from the initial dive was too slow. The eight-fin torpedo exhibited steadier water travel characteristics than the four-fin torpedo, but it took 800 yards to reach a steady depth level. The four-fin torpedo took only 380 yards to assume its proper depth level. As a result of the experiments, eight fins were abandoned for aircraft torpedoes.

The Japanese considered the small anti-roll flippers on each side of the torpedo as one of the most important features. The use of these roll stabilizers enabled them to carry a full charge of explosive in the warhead, and they also were responsible for eliminating the hook when the torpedo entered the water. The anti-roll stabilizers are discussed more completely in Part II of this report.

In 1941 some experiments were made with a jet-propelled torpedo, and in 1944 with a rocket torpedo. From 1943 to the end of the war the Japanese experimented with "KURAI" gliding torpedo bombs. All these experimental torpedoes are covered in detail in Part III of this report.

In 1944 experiments were made in an effort to develop an aircraft torpedo using hydrogen peroxide with hydrazine hydrate and kerosene. They were discontinued after a few months because of difficulties encountered in the handling of hydrogen peroxide.

Two-stage reducers were used in all the Type 91 torpedoes because they produced a very stable reduced air pressure. They were complicated and difficult to manufacture, so a one-stage reducer was used in the Type 4 torpedo. This was considered satisfactory and much simpler to produce than the two-stage type.

The great shortage of copper in Japan necessitated the replacement of all possible bronze parts with steel. This resulted in much difficulty with overhaul and preservation of torpedoes, which were stored for long periods of time.

From the end of 1944 until April 1945, about 200 Type 4 torpedoes were produced. They were practically the same as the Type 91 torpedoes, but were stronger and simplified in design for ease in production and handling. No information was obtained on service results.

The weak points of the torpedo at water entry are in the warhead joint, and in the shell or the engine room and buoyancy chamber. When the entrance angle is too low due to high speed and low altitude, the torpedo skips and buckles in the vicinity of the buoyancy chamber.

Many experiments were made with net cutters on the nose of torpedoes, but were unsuccessful because of rudder disturbance caused by excessive cavitation from the net cutters.

No figure-run devices were used on aircraft torpedoes.

Only the main parts of the torpedo, such as the air vessel, afterbody, and tail section were interchangeable. The warheads were not interchangeable with different modifications of aircraft torpedoes. The heaviest types were used in land-based torpedo planes and the lightest ones in carrier-based aircraft.

Cold weather experiments were conducted in Hokkaido and northern Korea. The main problem was lubricating oil, but a special oil developed at the First Naval Fuel Depot at OFUNA, performed satisfactorily. The tests consisted of taking the torpedo up to an altitude of 13,000 feet then descending quickly

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and launching the torpedo.

Hot weather experiments were made in the vicinity of Singapore. Rust and storage problems were investigated. It was found that without a thick coating of grease, rust formed within two hours after the torpedo was exposed to the tropical atmosphere. Painted warheads were left exposed in the sun and atmosphere for a period of one year and were still in satisfactory condition after that time.

Rear Admiral NARUSE stated that seven Type 91, Modifications 1 and 2, torpedoes sank HMS PRINCE OF WALES, and seventeen of the same type and modifications sank HMS REPULSE. This was the only information obtainable on service results of Japanese aircraft torpedoes.

EXPLANATION OF JAPANESE SYSTEM FOR CLASSIFYING AIRCRAFT TORPEDOES

The term TYPE is used to designate a particular design of torpedo and corresponds to the American and British term "MARK". The type number refers to the year in which the design was started. Thus, Type 91 refers to the Japanese year 2591 or 1931 A.D.

The term MODIFICATION is added whenever the size of warhead is changed. Some minor details of the torpedo may also be modified, but the main differences between Type 91, Modifications 1, 2, and 3, are in warhead sizes. The type and modification numbers apply to the whole torpedo including the warhead.

When Type 91, Modification 3, was strengthened to allow a higher launching speed, the term IMPROVED was added.

Still further strengthening caused the term STRONG to be added in place of IMPROVED. The aircraft torpedo was then designated as the Type 91, Modification 3, STRONG. The only differences between Type 91, Modifications 3, 4, and 7 (strong) are in the size of warhead used.

In 1944 (Japanese year 2604) the Type 91 aircraft torpedo was greatly strengthened and also simplified in construction, for ease of manufacture and production. (The degree of simplification is discussed later.) It was then designated as the Type 4 aircraft torpedo.

The term MODEL is sometimes used in connection with aircraft torpedoes, and refers only to the method of propulsion.

- Model 1 - Ordinary type of aircraft torpedo
- Models 2-3 - Jet-propelled torpedoes
- Models 4-8 - Bomb-torpedoes with no propulsion

Both the terms MARK and TYPE are used in designating warheads. Therefore, it is important to note that warheads Mark 4 and Type 4 are distinctly different.

The Japanese admit their system of classifying torpedoes and torpedo components is confusing, even to themselves. For example, the Type 4 aircraft torpedo is sometimes designated as the Type 4, Model 1, Mark 2 torpedo. It is really only a Type 4 torpedo with a Mark 2 warhead.

Part II

JAPANESE AIRCRAFT TORPEDOES IN OPERATIONAL USE DURING WORLD WAR II

A. Principal Differences in Japanese Aircraft Torpedoes

The following is a list of all the types and modifications of aircraft torpedoes which were in operational use, with the year they appeared and the principal changes made over the preceding type. A complete list of particulars is

given in Tables I through XI.

1. Type 91 Modification 2 (1941)

Explosive charge increased from 330 to 450 lbs.
Thickness of air vessel reduced from 7.0mm to 6.1mm.
Anti-roll stabilizers first adopted.

2. Type 91 Modification 3 (1942)

Explosive charge increased to 528 lbs.
Thickness of air vessel increased to 2mm.
Air vessel charging pressure increased to 180 kg/cm² (2560 psi).
Eight tail fins tried on some.
Bronze parts replaced with steel where possible.
Pendulum weight increased from 11.6 to 13.9 lbs.

3. Type 91 Modification 3 (Improved) (1943)

Top side afterbody and engine room strengthened with longitudinal T-shaped bars.
Maximum launching speed increased to 300 knots.

4. Type 91 Modification 3 (Strong) (1944)

Top side of afterbody strengthened with I-shaped bars instead of T-shaped bars.
Underside of warhead nose strengthened with I-shaped bars.
Maximum launching speed increased to 350 knots.
Thickness of air vessel decreased from 7.0mm to 6.1mm.
Air vessel charging pressure decreased to 160 kg/cm² (2280 psi).
Range decreased to 1500 meters (1640 yards).

5. Type 91 Modification 4 (Strong) (1944)

Explosive charge increased to 675 lbs.

6. Type 91 Modification 7 (Strong) (1944)

Explosive charge increased to 920 lbs.

7. Type 4 (April 1945)

Further strengthening.
Maximum launching speed increased to 400 knots.
Weight of pendulum increased from 13.0 to 16.5 lbs.
Effective area of diaphragm increased.
Servomotor for horizontal rudder mounted under depth gear for ease in removing.
One-stage reducer instead of two-stage.
Improved type of free-wheeling for propellers.
Oil distributor removed. Direct pipe leads with nozzles used instead.
Horizontal rudders strengthened.
Same type gyro used for steering and anti-roll stabilizers.
All possible parts simplified in design for maximum production.
All phosphor-bronze parts changed to steel wherever possible.

B. Air Vessel

The air vessel is a forged steel cylinder with the after bulkhead formed as part of the original forging. The forward bulkhead is removable and held in place by eight bolts. A fish paper gasket is used in the joint, and high

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Table I
JAPANESE AIRCRAFT TORPEDOES
Description and Performance Data

| | | Type 91 | | | | | | | Type 4 | |
|---------------------------------|--------|----------|----------|----------|------------------------|----------------------|----------------------|----------------------|-------------------|-------------------|
| | | Modif. 1 | Modif. 2 | Modif. 3 | Modif. 3 (Improved) | Modif. 3 (strong) | Modif. 4 (strong) | Modif. 7 (strong) | Warhead Mark 2 | Warhead Mark 4 |
| Wt. of explosive charge | lbs. | 330 | 450 | 530 | 530 | 530 | 680 | 925 | 670 | 920 |
| Total weight of warhead | lbs. | 473 | 610 | 725 | 725 | 725 | 860 | 1150 | 920 | 1190 |
| Length of war- head | inches | 37.8 | 45.6 | 57.5 | 57.5 | 57.5 | 57.5 | 74.8 | 57.5 | 74.8 |
| Total length | inches | 207.7 | 216.0 | 207.7 | 207.7 | 207.7 | 207.7 | 225.0 | 207.7 | 225.0 |
| Diameter | inches | 17.71 | 17.71 | 17.71 | 17.71 | 17.71 | 17.71 | 17.71 | 17.71 | 17.71 |
| Total weight | lbs. | 1728 | 1840 | 1872 | 1890 | 1890 | 2030 | 2320 | 2170 | 2435 |
| Displacement | lbs. | 1500 | 1568 | 1492 | 1492 | 1492 | 1492 | 1656 | 1480 | 1636 |
| Negative buoyancy | lbs. | 228 | 272 | 380 | 398 | 398 | 538 | 664 | 690 | 799 |
| C.G. from tail end | inches | 118.2 | 122.8 | 118.5 | 120.0 | 120.0 | 121.2 | 134.4 | 121.2 | 131.5 |
| C.B. from tail end | inches | 118.0 | 122.0 | 118.2 | 118.2 | 118.2 | 118.2 | 126.8 | 117.7 | 126.2 |
| Trim | inches | -0.2 | -0.8 | -0.3 | -1.8 | -1.8 | -3.0 | -8.1 | -3.5 | -5.3 |
| Specific weight | | 1.15 | 1.17 | 1.25 | 1.26 | 1.26 | 1.36 | 1.40 | 1.46 | 1.49 |
| Pull around | lbs. | 79.4 | 81.5 | 99.0 | 63.0 | 61.5 | 7.5 | 8.35 | 20.2 | 20.2 |
| Horsepower | | 140 | 140 | 140 | 140 | 140 | 140 | 140 | 140 | 140 |
| Speed | knots | 42 | 42 | 42 | 42 | 42 | 42 | 41 | 42 | 41 |
| Range | yards | 2200 | 2200 | 2200 | 2200 | 1640 | 1640 | 1640 | 1640 | 1640 |
| Maximum launch- ing velocity | knots | 260 | 260 | 260 | 300 | 350 | 350 | 350 | 400 | 400 |

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Table II
JAPANESE AIRCRAFT TORPEDOES
Air Vessel

| | Units | Type 91 | | Type 4 |
|------------------|---------|------------|----------|--------|
| | | Modif. 3 | | |
| | | (improved) | (strong) | |
| Charged pressure | psi. | 2560 | 2275 | 2275 |
| Volume | cu. ft. | 6.45 | 6.47 | 6.47 |
| Wt. of air | lbs. | 83.7 | 73.0 | 73.0 |
| Wall thickness | inches | 0.276 | 0.240 | 0.240 |
| Length | inches | 42.1 | 42.1 | 42.1 |

Table III
JAPANESE AIRCRAFT TORPEDOES
Liquid Capacities

| | Units | Type 91 | | Type 4 |
|---------------|-------|------------|----------|--------|
| | | Modif. 3 | | |
| | | (improved) | (strong) | |
| Vol. of water | pints | 30 | 30 | 30 |
| Vol. of fuel | pints | 8.65 | 8.65 | 7.40 |
| Vol. of oil | pints | 6.75 | 6.75 | 6.32 |

Table IV
JAPANESE AIRCRAFT TORPEDOES
Reducer

| | Units | Type 91 | | Type 4 |
|----------|-------|------------|----------|---------|
| | | Modif. 3 | | |
| | | (improved) | (strong) | |
| Type | | 2-stage | 2-stage | 1-stage |
| Pressure | psi | 570 | 570 | 570 |

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Table V
JAPANESE AIRCRAFT TORPEDOES
Engine

| | Units | Modif. 3 | | Type 4 |
|-------------------------------------|-----------|------------------|------------------|------------------|
| | | (improved) | (strong) | |
| Type | | 8-cyl. radial | 8-cyl. radial | 8-cyl. radial |
| Weight | lbs. | 183 | 183 | 174 |
| Cylinder bore | inches | 3.54 | 3.54 | 3.54 |
| Stroke | inches | 3.34 | 3.34 | 3.34 |
| Inlet pressure | psi. | 570 | 570 | 570 |
| Engine timing expansion ratio | % | 37 | 37 | 37 |
| Max. horse- power | | 210 | 210 | 210 |
| RPM at max. hp | | 1260 | 1260 | 1260 |
| Air efficiency | hp/lb/sec | 550 | 550 | 550 |

Table VI
JAPANESE AIRCRAFT TORPEDOES
Combustion Chamber

| | Units | Modif. 3 | | Type 4 |
|------------------------|---------|------------|----------|---------|
| | | (improved) | (strong) | |
| Volume | cu. ft. | 0.05 | 0.05 | 0.049 |
| Air to fuel ratio | | 10-12.5 | 10-12.5 | 10-12.5 |
| No. of igniters | 1 | 2 | 2 | 2 |
| Air consump- tion | lbs/sec | 0.485 | 0.485 | 0.485 |
| Water to fuel ratio | | 3.5 | 3.5 | 3.5 |

Table VII
JAPANESE AIRCRAFT TORPEDOES
Shell Thickness

| | Units | Modif. 3 | | Type 4 |
|------------------|--------------|-----------------------|-----------------------|-----------------------|
| | | (improved) | (strong) | |
| Buoyancy chamber | milli-meters | top - 2 bottom - 3 | 3.0 | 3.0 |
| Engineroom | milli-meters | top - 2 bottom - 3 | 3.0 | 3.0 |
| Afterbody | milli-meters | top - 2 bottom - 3 | front-3.5 rear-3.0 | front-3.5 rear-3.0 |
| Tail cone | milli-meters | 2.5 | 2.5 | 2.5 |

Table VIII
JAPANESE AIRCRAFT TORPEDOES
Depth Gear

| | Units | Modif. 3 | | Type 4 |
|------------------------|------------|------------|----------|--------|
| | | (improved) | (strong) | |
| Total wt. | lbs. | 30.8 | 30.8 | 28.6 |
| Wt. of pendulum | lbs | 13.9 | 13.9 | 16.5 |
| Eff. area of diaphragm | sq. inches | 3.04 | 3.04 | 2.57 |
| Depth setting | feet. | 6.5-65 | 6.5-65 | 6.5-65 |

Table IX
JAPANESE AIRCRAFT TORPEDOES
Propellers

| | Units | Modif. 3 | | Type 4 |
|--------------------------|--------|------------|----------|--------|
| | | (improved) | (strong) | |
| No. of props. | | 2 | 2 | 2 |
| No. of blades each prop. | | 4 | 4 | 4 |
| Diam. of forw'd prop. | inches | 15 | 15 | 15 |
| Diam. of after prop. | inches | 13.5 | 13.5 | 13.5 |

Table X
JAPANESE AIRCRAFT TORPEDOES
Passing Conditions

| | Units | Modif. 3 | | Type 4 |
|------------------|-------|----------------------|----------------------|----------------------|
| | | (improved) | (strong) | |
| Speed | knots | 42 \pm 1 | 42 \pm 1 | 42 \pm 1 |
| Range & over run | yards | 2200 +10% | 1640 +10% | 1640 +10% |
| Depth keeping | feet | \pm 1.5 | \pm 1.5 | \pm 1.5 |
| Deflection | yards | \pm 1% of range | \pm 1% of range | \pm 1% of range |

pressure air tightly seals the bulkhead against the air vessel flange. The forward bulkhead may be removed in a similar manner to bulkheads in U.S. torpedoes by rotating and withdrawing through two slots.

Air vessels on torpedoes prior to the Type 91, Modification 3 (Strong) were fitted with drain plugs, but the later models had none as only dry air was used. Silica-gel was used to remove the moisture from the air before charging.

A heavy mineral oil was originally used to preserve the internal ground surface of air vessels, but later a "liquid grease" was adopted. This "liquid grease" was developed at the First Naval Fuel Depot at OFUNA.

The main air pipe is made of standard A.R. copper and fits into the center of the after bulkhead with a knife-edge joint. No difficulties were experienced with air vessel leaks.

The thickness of air vessels varied from 6.1mm to 7mm (0.240 to 0.276 in), and the design safety factor from 1.89 to 1.93.

In order to strengthen further the torpedo and still maintain the same total weight, the thickness of the air vessel was decreased in the Type 91, Modification 3 (Strong).

Air vessels were manufactured at different factories, and three main types of steel were used consistently. The compositions of and specifications for the three types of steel are given in Tables XII and XIII.

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Table XI
JAPANESE AIRCRAFT TORPEDOES

| Torpedo | Warhead | Torpedo plus Warhead | Exploder | Exercise Head | Gyro |
|-----------------------------|---------------------------|--|--------------------------|---------------------------|------------------|
| Type 91 Modif. 1 | Type 91 Modif. 1 | Type 91 Modif. 1 | Type 90 Model 2 | Type 91 Modif. 1 | Type 91 |
| Type 91 Modif. 2 | Type 91 Modif. 2 | Type 91 Modif. 2 | Type 90 Model 2 | Type 91 Modif. 2 | Type 91 |
| Type 91 Modif. 3 | Type 91 Modif. 3 | Type 91 Modif. 3 | Type 90 Model 2 | Type 91 Modif. 3 | Type 91 |
| Type 91 Modif. 3 (improved) | Type 91 Modif. 3 | Type 91 Modif. 3 (improved) | Type 90 Model 2 | Type 91 Modif. 3 | Type 91 Modif. 1 |
| Type 91 Modif. 3 (strong) | Type 91 Modif. 3 (strong) | Type 91 Modif. 3 (strong) | Type 90 Model 2 (strong) | Type 91 Modif. 3 (strong) | Type 91 (strong) |
| Type 91 Modif. 3 (strong) | Type 91 Modif. 4 | Type 91 Modif. 4 (strong) | Type 90 Model 2 (strong) | Type 91 Modif. 4 | Type 91 (strong) |
| Type 91 Modif. 3 (strong) | Type 91 Modif. 7 | Type 91 Modif. 7 (strong) | Type 90 Model 2 (strong) | Type 91 Modif. 7 | Type 91 (strong) |
| Type 91 Modif. 3 (strong) | Type 3 (kite) | Type 91 Modif. 3 (strong) with type 3 head | Type 90 Model 2 (strong) | Type 3 | Type 91 (strong) |
| Type 91 Modif. 3 (strong) | Type 4 (V-head) | Type 91 Modif. 3 (strong) with type 4 head | Type 90 Model 2 (strong) | none | Type 91 (strong) |
| Type 4 | Mark 2 | Type 4 Mark 2 | Type 4 | Mark 2 | Type 4 |
| Type 4 | Mark 4 | Type 4 Mark 4 | Type 4 | Mark 4 | Type 4 |
| Type 4 | Type 3 (kite) | Type 4 with type 3 head | Type 4 | Type 3 | Type 4 |
| Type 4 | Type 4 (V-head) | Type 4 with type 4 head | Type 4 | none | Type 4 |

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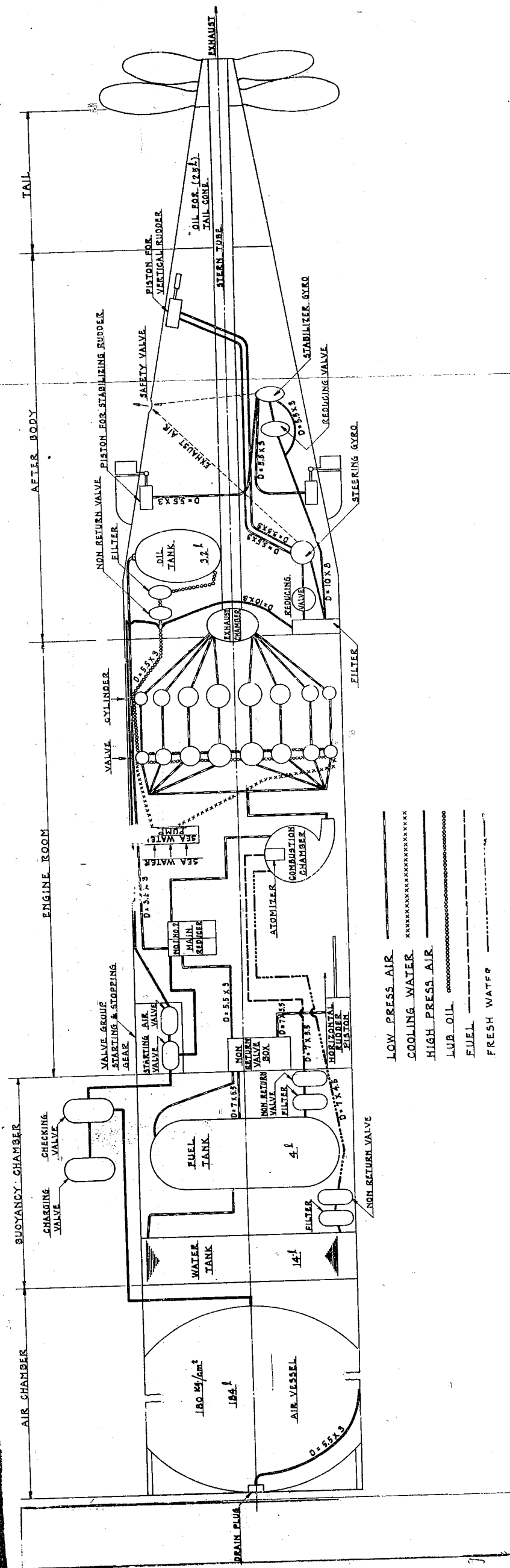


Figure 1
SCHEMATIC DIAGRAM FOR TYPE 91 MODIF. 3 TORPEDO

Table XII
COMPOSITION (%) OF STEEL FOR AIR VESSELS

| Steel Type No. | C | Si | Mn | Ni | Cr | Cu | Mo |
|----------------|------|------|-----|-----|-----|-----|-----|
| V7 | 0.25 | 0.25 | 0.8 | 1.8 | 1.0 | 1.0 | 0.5 |
| SK | 0.35 | 1.0 | 1.0 | | 1.2 | | 0.4 |
| V9 | 0.30 | 0.25 | 1.0 | 1.0 | 1.0 | 0.4 | 0.3 |

Table XIII
MINIMUM SPECIFICATIONS FOR STEEL FOR AIR VESSELS

| Steel Type No. | Breaking Strength (psi) | Elastic Limit (psi) | Izod Shock Value (ft lbs) |
|----------------|----------------------------|------------------------|------------------------------|
| V7 | 157,000 | 142,200 | 22 |
| SK | 157,000 | 142,200 | 22 |
| V9 | 157,000 | 142,200 | 22 |

In hydraulic bursting tests, air vessels withstood approximately six times the normal working pressure before failing.

A bayonet joint ring secures the head to the air vessel, the midship section to the afterbody, and the after body to the tail. Geared racks, which have to be turned by special tools, rotate the rings to lock or unlock the bayonet joint. The midship section is screwed to the air vessel and sweated.

C. Midship Section

The midship section is divided into two sections, separated by a bulkhead. The forward part is a watertight buoyancy chamber, 29" long, and the after part allows admittance of sea water. The buoyancy chamber contains two water bottles, a fuel bottle, depth mechanism, a relief valve, and stop and charging valves. The after section contains a depth-keeping servomotor, controlling gear, starting valve, combined non-return valve, and also forms a housing for the engine when the afterbody is coupled to the midship section.

D. Afterbody

The afterbody contains a relief valve, a lubricating oil bottle, two disc reducers, gyroscope and steering engine for operating the vertical rudders, and gyroscope and two steering engines for operating the anti-roll rudders. Fitted on the forward bulkhead, but outside the buoyancy chamber, are the engine, main reducer and combustion chamber.

E. Tail

The tail is a conical steel forging fitted with vertical and horizontal fins and rudders. The tail body, which is a water-tight compartment, is filled with oil to provide lubrication to the gearing.

F. High Pressure Air System

High Pressure air passes from the air vessel past the open stop valve, to the starting valves. There are two starting valves. The small valve is opened by means of a cam on the end of a section of a geared wheel. When the torpedo is secured to the aircraft, this section of gear wheel is meshed in a rack fixed to the aircraft. When the torpedo is released, the gear wheel is revolved and the cam is forced against a lever which opens the small valve. High Pressure air then passes to the two gyros which are started and uncocked by this air blast. The large valve is opened by means of a water flap, which does not operate until the torpedo strikes the water. High Pressure air is admitted, past this valve, to the main reducer and from there to the combustion chamber.

G. Main Reducer

The main reducer is a two-stage plunger type in which high pressure air is reduced in the first stage, and further reduced in the second stage. Two small oil bottles form part of the reducer casting, each stage being lubricated by its own oil bottle. High pressure air is led into the top of the first bottle, forcing oil into the bottom of the first stage. Reduced pressure air, after it has left the first stage, forces oil out of the second bottle into the bottom of the second stage.

H. Reduced Air System

Air from the low pressure side of the main reducer is led past a combined non-return valve to the water and fuel bottles, forcing these liquids out under pressure, past a strainer and non-return valve, to the combustion chamber. A branch pipe leading from the top of the combined non-return valve admits reduced air to the depth-keeping servomotor. Another pipe from the low pressure side of the main reducer leads past a non-return valve to the top of the lubricating oil bottle, forcing the oil out to the oil distributor. A continuation of the blast high pressure air pipe to the steering gyro, is led to a disc reducer. The reduced air from this disc reducer impinges on the gyro wheel, thus maintaining the wheel speed. A separate pipe allows high pressure air to reach the disc reducer of the anti-roll gyro.

I. Combustion Chamber

The combustion chambers in torpedoes up to and including the Type 91, Modification 3, were made of 18-8 stainless steel, but changed to ordinary mild steel in all the later types.

The chamber head was originally a phosphor-bronze casting and later changed to 13% chromium steel. The chamber head is screwed and soldered to the main flask, and no difficulties have been experienced with this joint. The pipes leading from the chamber to the engine are always made of the same material as the chamber, and connected to it by a knife-edge joint with a copper gasket.

Steel used in combustion chambers must have a carbon content less than 0.15% to eliminate cracking.

The flame temperature within the chamber was never measured, but the wall temperature does not exceed 100°C during combustion. The temperature of the gases entering the engine inlet valves ranges from 500-600°C.

The main air supply enters the top of the chamber head, with 60% entering the chamber through a steel baffle plate, and 40% passing through the fuel sprayer.

Water enters the chamber through a series of small holes outside the steel baffle plate.

The fuel sprayer is similar in design to that of the Whitehead torpedo, with fuel passing thru the center of the sprayer and discharging radially from seven small holes. Above the sprayer is a rated nozzle with a 100 mesh strainer on top of it. Air enters the space between the fuel nozzle body and the fuel sprayer, and is discharged into the chamber from just behind the spray holes.

The rating figures for the combustion chamber, using water with a feed pressure of 1 kg/cm² (14.22 psi) for 120 seconds, are as shown in Table XIV.

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Table XIV
RATING FIGURES FOR THE COMBUSTION CHAMBER

| | Type 91, Modif. 3 (Improved) | Type 91, Modif. 3 (Strong) | Type 4 |
|--------------------|---------------------------------|-------------------------------|-------------|
| Water | 9.9 pints | 10.1 pints | 10.1 pints |
| Fuel | 3.8 pints | 3.8 pints | 3.8 pints |
| Main Air Passage | 142.0 pints | 143.0 pints | 139.0 pints |
| Air For fuel Spray | 38.2 pints | 38.5 pints | 36.8 pints |

Two ignitors are fitted in the head of the chamber, and are fired by two spring hammers released by the revolution of a cam shaft, through an adjustable ignition delay. The cam shaft is driven by the gearing on the forward engine cover.

J. Range and Speed Adjustments

There is no speed adjustment on the combustion chamber, or on the reducer, and, therefore, the torpedo had a single speed.

The range gear wheel is graduated from 0 to 5000 meters, and is driven by gearing from the engine. As the engine runs, a disc clutch revolves until a stop pin moves into a hole in the clutch. This stop pin is secured to a lever in contact with the large starting valve, and when the stop pin enters the hole in the clutch the large starting valve closes and stops the engine.

K. Engine

1. Combustion Manifold: Each outlet from the generator supplies four cylinders through pipes having 25mm (.985") inside diameter. Each pipe bifurcates twice, supplying one pair of forward and one pair of rear cylinders. The pipes are of welded construction and are bolted to the generator and heads. Much trouble has been experienced with joints due to expansion from heat. The excessive length of the piping results in undue heat losses and explains why so low a water to fuel ratio as 3.5 can be used without damage to the engine.

2. Cylinder Heads: These are phosphor-bronze castings with the thread for the union nut cut in the casting. The head is screwed onto the top of the detachable steel liner. Considerable difficulty has been experienced with pipe connections, due to the necessity for screwing the heads up to a line. A plug is screwed into the center of the head; the hole being required to obtain the timing.

The valve cap joint is made with a fibre washer.

The valve seats are detachable and are screwed into the valve chest.

Integral with the seats are the valve guides, both being of phosphor-bronze. The joint at the bottom is knife edged, and the thread makes the joint at the top. The seat is not locked in place. This arrangement is poor, because it is impossible to keep the joints tight due to the unequal expansion. There are four ports, 9mm (.355") wide and 16mm (.630") long.

3. Valves: The valve is of the standard poppet design, except that a flat seat is used instead of the normal conical one. In the head of the valve is a square recess and a threaded hole for extraction purposes.

The valve stem has four oil grooves.

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The valve springs are of bronze and are totally enclosed; they are retained in place by a spring cap positioned by a square on the rear end of the stem.

The leading particulars are:

Diameter of head valve 40mm (1.58")
Lift 6mm (0.236")

4. Cylinder Liners: These are detachable, and are of steel, having a machined flange two-thirds from the bottom. They are bolted into the body, as well as screwed into the head. The main exhaust ports consist of two rows of holes.

The main details are:

Bore 90mm (3.55")
Thickness 3mm (.118")
Exhaust ports
1st row - diameter 8mm (.315")
 number 20
2nd row - diameter 6mm (.236")
 number 20

5. Pistons: The material of the piston is bronze. The piston is of the aircraft type with no skirt, but only thrust pads. They are fitted with a single cast iron ring. There are two gudgeon exhaust ports in the crown.

A bronze shell is inserted in the knuckle end to form the bearing surface. Principal data are as follows:

Diameter 89.5mm (3.526")
Clearance5mm (.0197")
Exhaust ports
Width 4mm (.158")
Length 35mm (1.38")
Piston Ring
Width 8mm (.315")
Thickness 2.5mm (.10")

6. Connecting Rod: This is of H-section steel, having ports in the knuckle end to suit those in the piston. The foot of the rod is unlined and has oil grooves and holes.

Length 46mm (1.81")
Width 21mm (0.83")

7. Crankshaft: The steel crankshaft has double-throw cranks at 180° with no intermediate bearing, and is made in two parts with the crank-cheek squares on the central web. These are locked in position by grub screws. The crank webs are recessed to form the retaining rings, and the cams are formed on the balance weights of the external webs.

The crankshaft is mounted on ball bearings at each end, and has a three splined drive for the propeller shaft. The two crank pin bushings are of bronze.

The main dimensions are.

| | |
|---------------------------------|-----------------|
| Forward bearing journals | |
| Diameter | 45mm (1.77") |
| Length | 21.5mm (0.85") |
| Crank pins | |
| Diameter | 35mm (1.379") |
| Crank pin bushing | |
| Internal diameter | 35.2mm (1.386") |
| External diameter | 41.5mm (1.64") |
| After bearing journal | |
| Diameter | 55mm (2.17") |
| Length | 25mm (0.99") |

8. Engine Casing: This steel casting, eight-sided, of 3.5mm thickness, is only machined to give joint faces. The cylinder liners slide in and are secured by nuts on the inside. Tappet lever brackets are screwed and sweated to it. Front and back covers are bolted to its flanged ends.

9. Front Cover: The front cover is a bronze casting bolted to the engine casing by 16 bolts, a fibre washer being used to make the joint. At its center is the forward bearing race. An extension from the main shaft passes through it to drive the water pump, oil distributor and upright shaft.

10. Rear Cover: This is of steel, and flanged to mount the engine in the afterbody. It is bolted to the engine casing in a manner similar to the front cover. It has the housing for the after crankshaft ball race, which is retained by a ring nut.

11. Engine Cooling: The external surface of the engine is cooled by sea water circulating through the engine room. The internal cooling is carried out by a water pump of the double shutter type. The delivery is through a non-return valve, discharging via a passage around the casting, through four outlets into the crankcase.

12. Engine Lubrication: Oil is supplied at reduced pressure to the two point oil distributor. One connection feeds oil to the eight valve stems, and the other feeds oil down through the center of the crankshaft to the two large end bearings. The lubrication of the ball bearings, pistons and knuckle ends is by splash.

13. Engine Timing: To time the engine, a bronze timing cover, graduated in degrees, is fitted in place of the front cover. A dummy spindle with a pointer is inserted in the forward journal.

L. Depth Mechanism

The depth gear is fitted in a separate removable watertight compartment in the buoyancy chamber. The gear consists of a hydrostatic valve and pendulum weight, and functions in a similar manner to depth gears in U.S. torpedoes. It also makes use of an air piston servomotor, similar to the U.S. type, which is connected by a rod to the two horizontal rudders.

An adjustable controlling gear is fitted to the servomotor, which locks the rudders until the engine starts. It is driven by gearing from the engine and can be adjusted to lock the rudders in position for different distances. The usual procedure was to lock the rudders in the "up" position for the first ten meters of water travel and free movement for the remainder of the run.

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M. Gyros

Two separate air-blast, air-sustained type gyros were used in each aircraft torpedo. One gyro controlled the steering and the other controlled the anti-roll stabilizers.

In all Type 91 torpedoes the stabilizer gyro was considered as part of the torpedo, and it had no special type number. It was just called the stabilizer gyro and was different from the steering gyro. In the Type 4 torpedo, however, both gyros were the same type in order to simplify the manufacture and adjustment of the torpedo.

Table IV lists the type gyro used with each type of aircraft torpedo.

The following lists all types and modifications of gyros with the date they appeared and the principal changes made over the preceding type.

1. Type 91 Modification 1 (1943)
 - a. Strength of the supporting frame was increased over that of Type 91.
2. Type 91 (Strong) (1944)
 - a. Strength of the horizontal bearings was increased by changing the radius of the pivots from .0118 inches to .0197 inches.
 - b. Diameter of the bottom vertical bearing was increased.
3. Type 4 (April 1945)
 - a. Horizontal pivot bearings were replaced with ball bearings for increased strength.
 - b. Different method of mounting to the torpedo was adopted.
 - c. Design was simplified for mass production.
 - d. This type used for both anti-roll stabilizers and steering control in the Type 4 torpedo.

N. Propellers

The propellers are made of either SK or Vg steel, and have a mean pitch of one meter. There is a straight line relationship between blade pitch and the distance along the radius. A section across the middle of the blade shows the driving surface as a straight line and the forward surface as a segment of a circle.

To prevent propeller damage when the torpedo enters the water, a ratchet-clutch method of free wheeling was adopted on the Type 91. (See Figure 2) This method was satisfactory for launching speeds up to 350 knots. At higher launching speeds, however, the clutch would not disengage due to inertia of the parts from the rapid deceleration of the torpedo.

An improved method of free-wheeling was adopted for the Type 4 torpedo. (See Figures 3 and 4) Centrifugal force of the engine shaft causes small bails to fly out and engage in a ratchet on the propeller shaft during normal running. When the RPM of the propeller shaft exceeds that of the engine shaft, the ratchet merely slides over the bails and depresses them, allowing the propellers to spin faster during the initial water travel. This design was highly regarded by the Japanese.

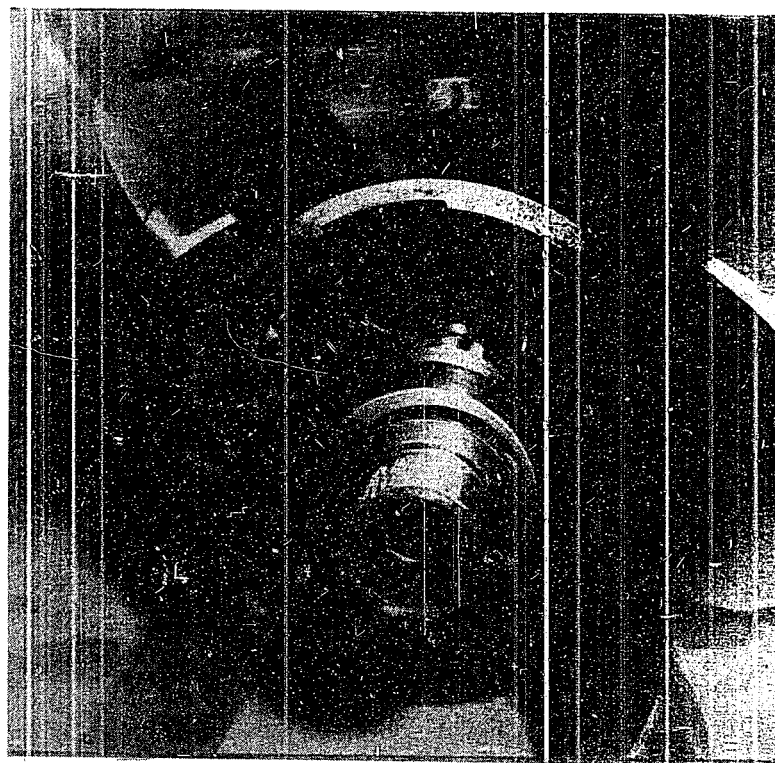
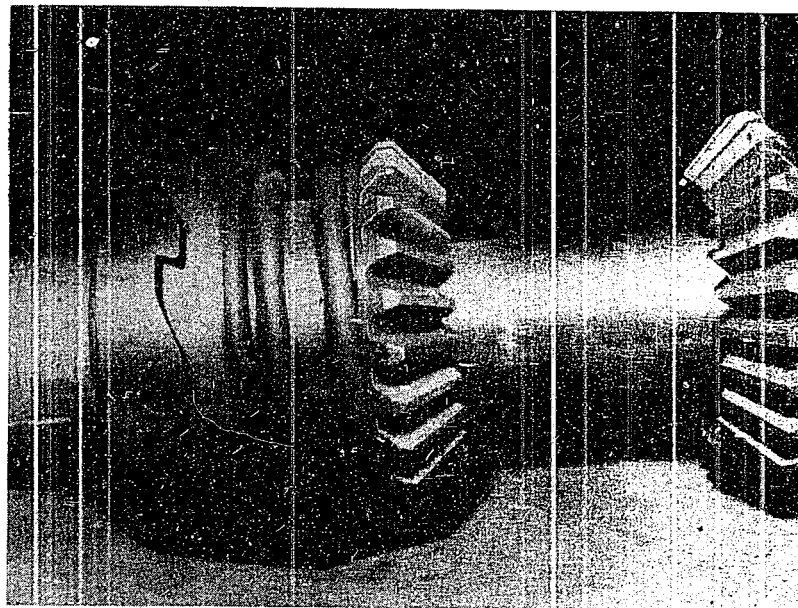


Figure 3
FREE-WHEELING PROPELLER ARRANGEMENT
IN TYPE 4 AIRCRAFT TORPEDO

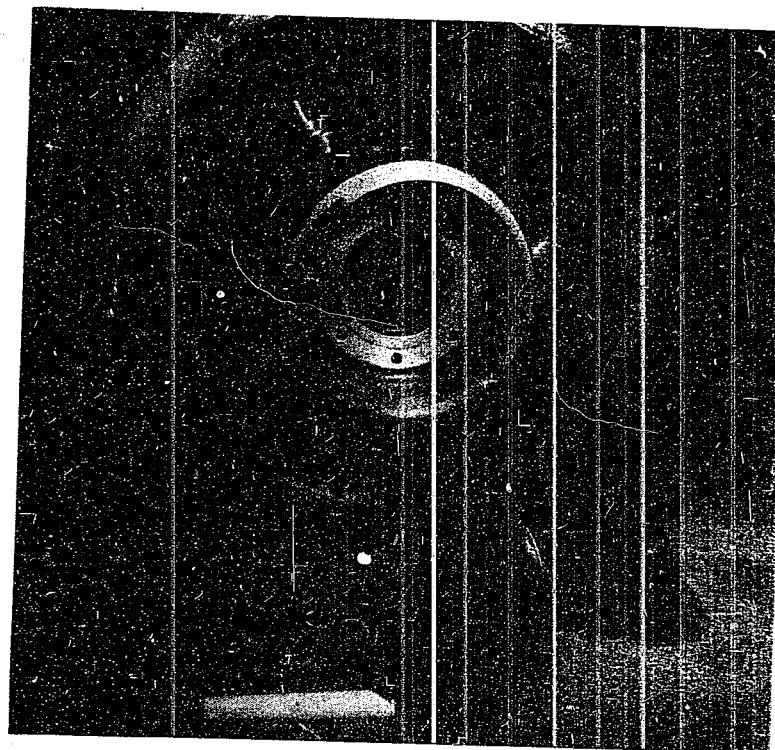


Figure 4
PARTS OF FREE-WHEELING PROPELLER SYSTEM
USED IN TYPE 4 AIRCRAFT TORPEDO

O. Anti-Roll Stabilizers

With the exception of Type 91, Modification 1, all Japanese aircraft torpedoes are fitted with small, gyro-controlled anti-roll flippers. This method was adopted in 1940 on the Type 91 Modification 2 torpedo and has been a permanent feature in all the later designs of aircraft torpedoes.

Before 1940, it was necessary to lower the torpedo's center of gravity as much as possible to minimize rolling. This resulted in partial filling of the warheads with explosive charge in order to concentrate the weight below the axis of the torpedo. The introduction of anti-roll flippers, however, made complete filling of warheads possible and gave the torpedo greater destructive capacity.

The torpedo is kept from rolling during air travel with the aid of wooden frames attached to the anti-roll flippers (see Figure 7). If rolling occurs, the horizontal rudders, which have "up rudder", act as steering rudders and cause the torpedo to "hook" sharply when it enters the water. The use of roll-stabilizers eliminated the "hook" and gave the torpedo excellent launching characteristics.

The Japanese claim that the use of roll-stabilizers was one of the most important features in the aircraft torpedo.

P. Air Stabilization

Japanese aircraft torpedoes are stabilized during air travel by means of wooden frames attached to the tail and to the anti-roll flippers on the sides of the afterbody. These frames break off when the torpedo enters the water.

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Two types of aerial tail frames were used:

1. Box-Type Tail Frame (See Figure 5): This type was similar to the wooden stabilizers used on U.S. aircraft torpedoes. It was very large and could not be used when the torpedo was carried in the bomb bay of aircraft. For this reason, and also because of the scarcity of large sheets of plywood, the Japanese planned to use only the X-Type tail frame in the future. The box-type frame, however, gave better performance and was used occasionally on torpedoes which were slung under the fuselage of a plane.

The frame was tilted diagonally and slid over the tail fins then righted and slid back until the fins fitted into the grooves on the frame. Air pressure held the frame firmly against the fins during air travel.

2. X-Type Tail Frame (See Figure 6): This type was slightly less effective but cheaper and easier to produce. It was held in place by small wooden blocks which were bolted on after the frame was placed over the tail fins. The main advantage was in its adaptability to all types of torpedo planes.

There were also two sizes of wooden frames for the anti-roll flippers. (See Figure 7) They were wing-shaped and consisted of two half sections bolted together around the flippers. The larger size was used originally, but a smaller type was finally adopted because of the restricted openings in bomb bays.

Figures 8 and 9 are charts for determining the entrance angles and velocities of aircraft torpedoes with variable launching conditions.

Figure 10 is a graph of pitching moment in air versus angle of incidence for various types of Japanese aircraft torpedoes.

Q. Warheads

1. General: All warheads for aircraft torpedoes were filled with Type 97 explosive, which was 60% TNT and 40% Hexyl.

In 1944 the Japanese started using the Type 3 "Kite" hydroplane warhead on aircraft torpedoes as a substitute for an influence-firing exploder. Briefly, it is a remote control method for obtaining detonation under a ship's hull by towing a small hydroplane above and slightly abaft the warhead. As the torpedo passes under a ship the hydroplane strikes the hull and breaks away thereby releasing the tow line tension and firing the exploder. All details, with illustrations of the "Kite" head, are given in Part VI, Chapter II of U.S. Navy Mine Disposal Handbook dated 1 November 1944 and published by the Mine Disposal School, U.S. Navy, Washington, D.C.

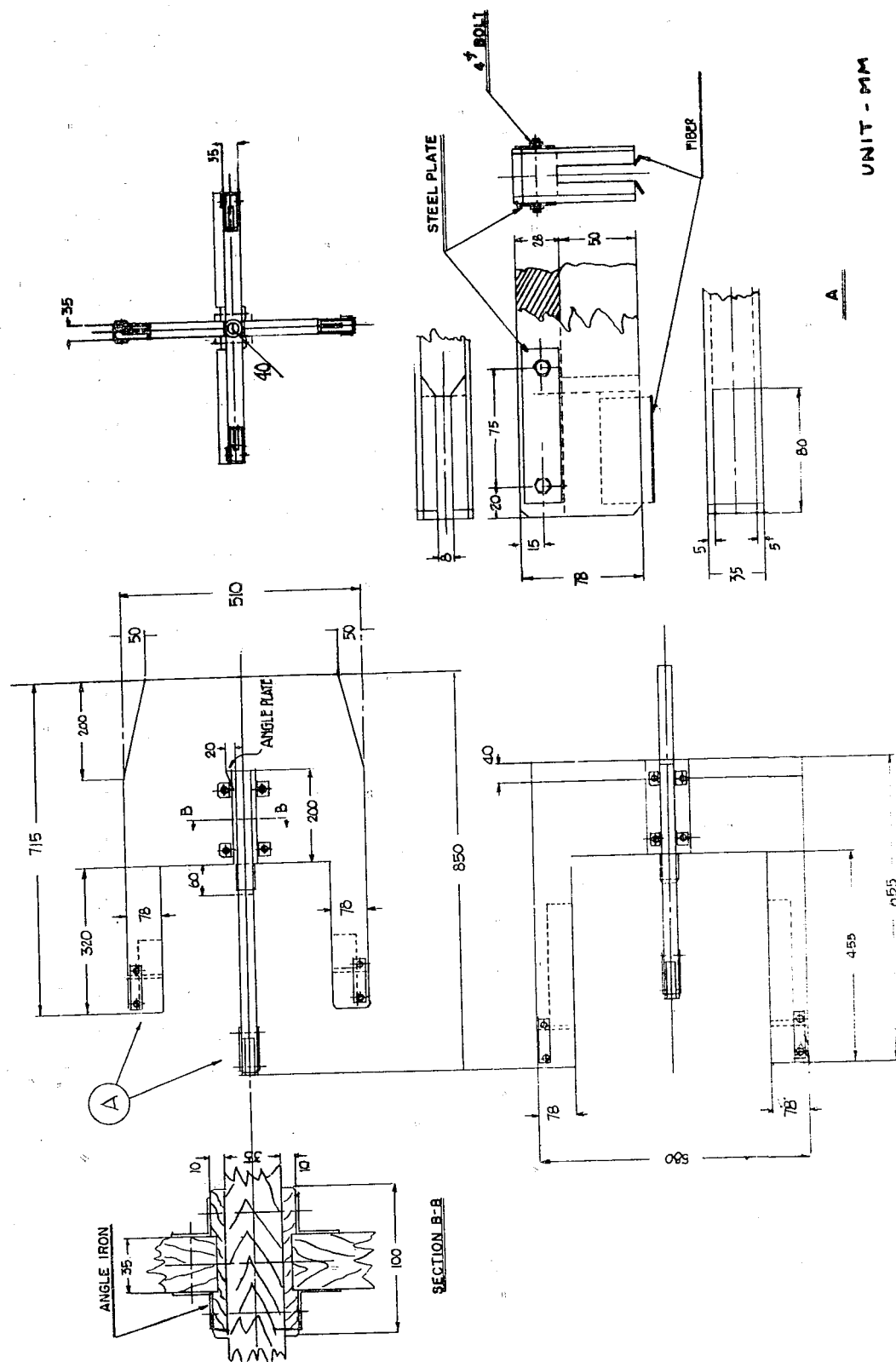
In 1945 the Type 4 shaped charge warhead appeared on aircraft torpedoes. The following summary describes the warhead and the preliminary experiments made during its development.

2. Japanese "V" - Warhead (Shaped Charge): In an effort to obtain greater penetrating effects against multilayer underwater protection systems, the Japanese developed a warhead using the principle called "Neuman's Effect".

The forward end of the bursting charge has a conical cavity which is lined with a funnel-shaped, carbon-steel piece having a tensile strength of 71,000 psi. (See Figure 12 for the details of construction). When the charge is detonated by an ordinary inertial type exploder, the

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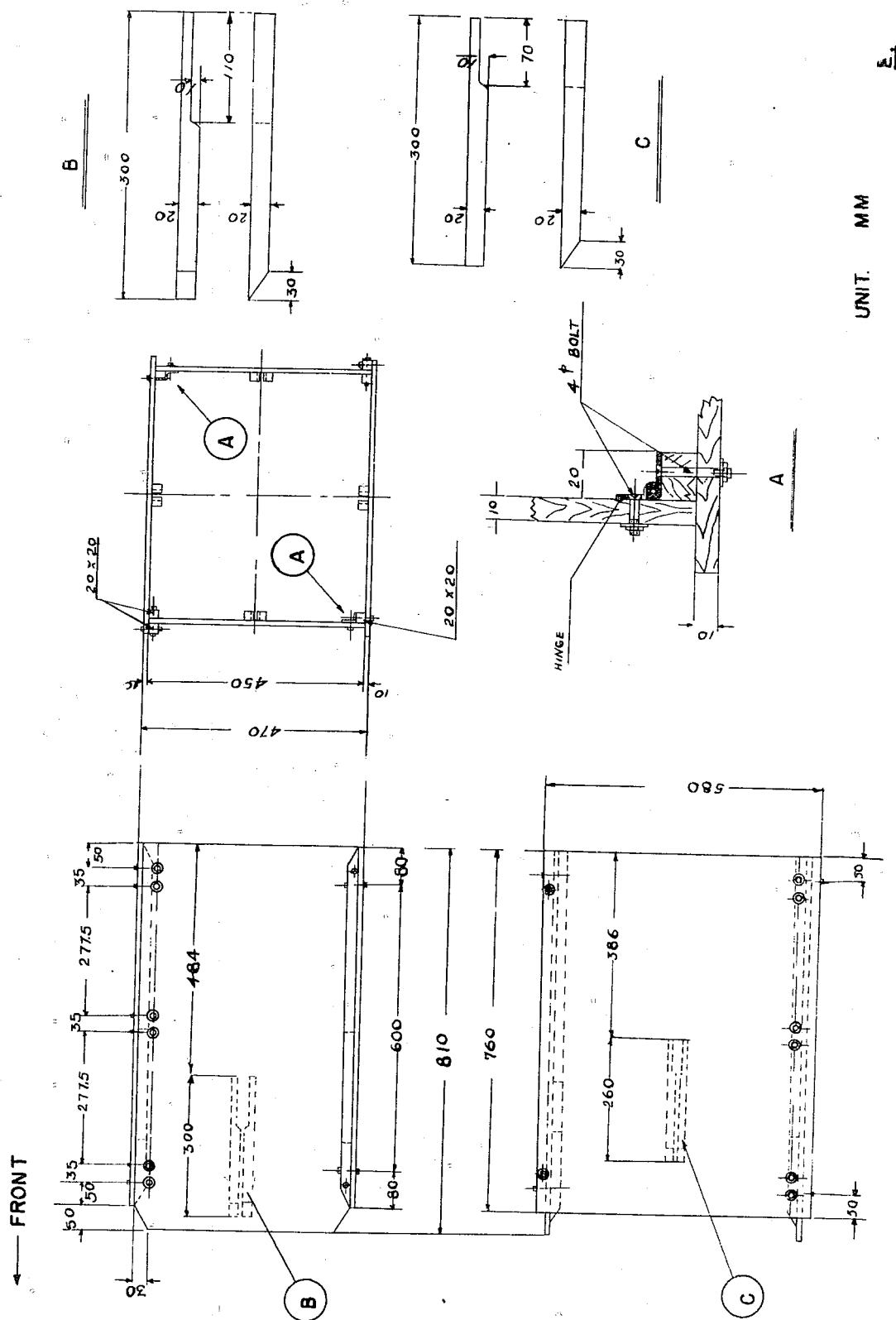


Figure 6
AERIAL TAIL FRAME (X-TYPE)

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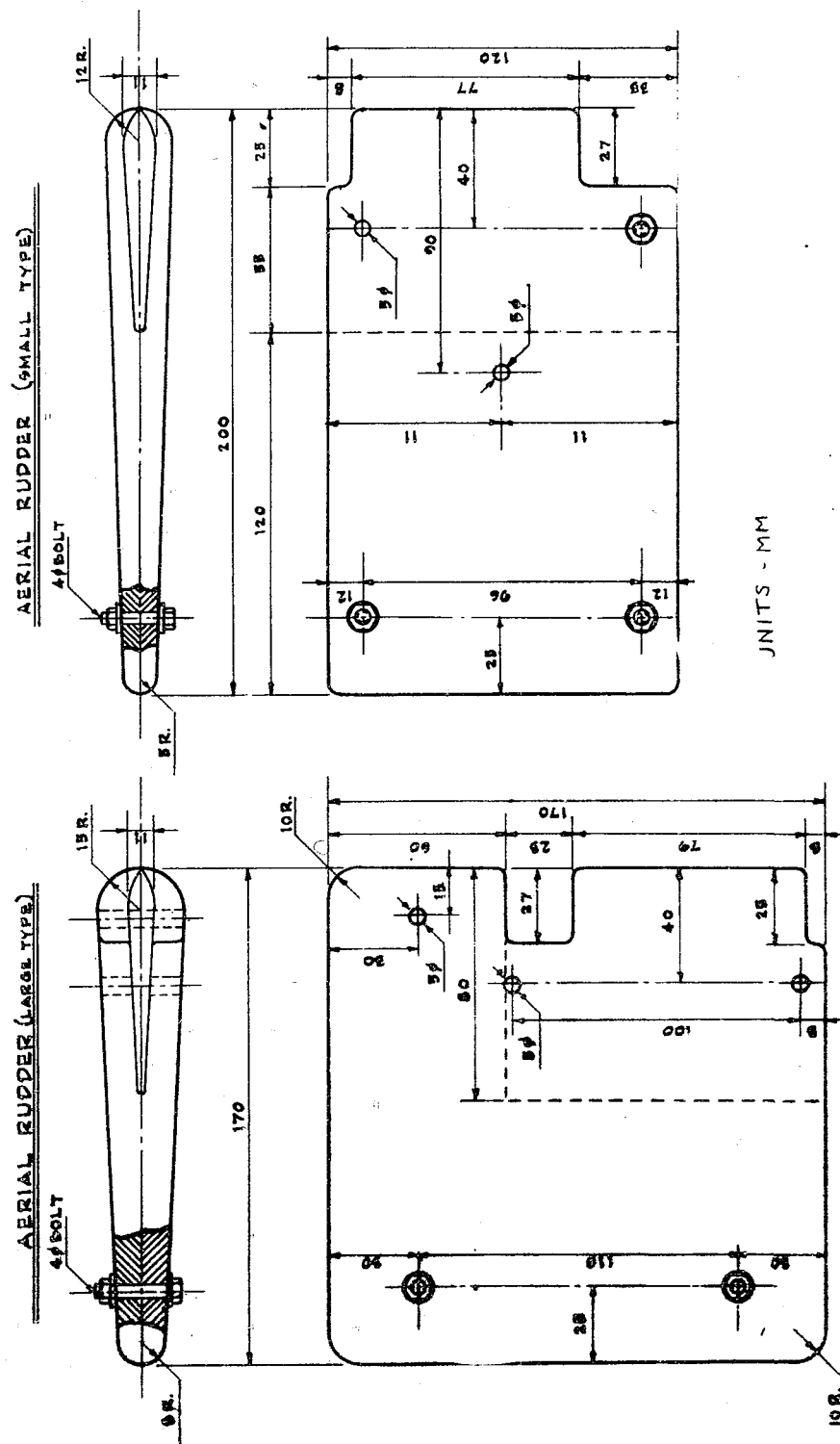


Figure 7
AERIAL RUDDER (LARGE AND SMALL TYPES)

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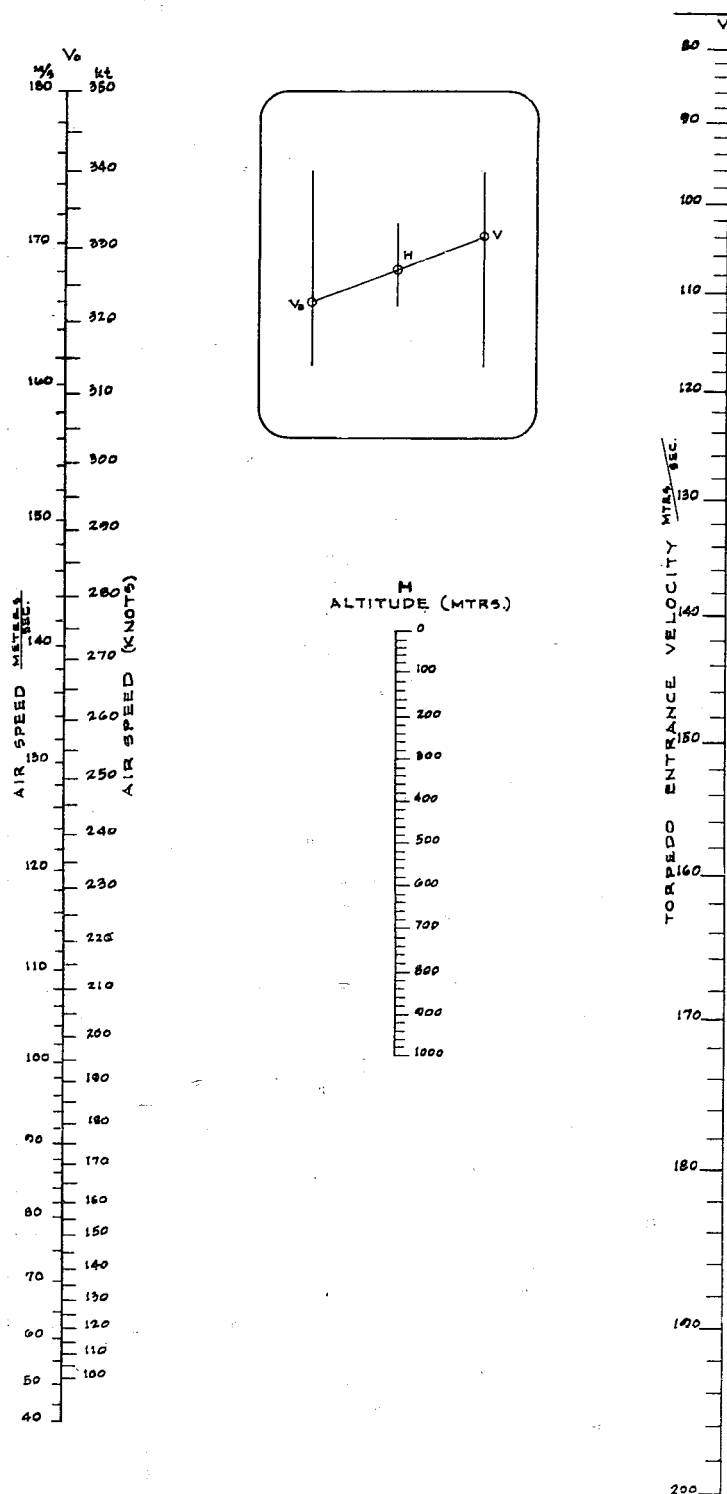


Figure 8
ENTRANCE VELOCITY CHART FOR JAPANESE AIRCRAFT TORPEDO

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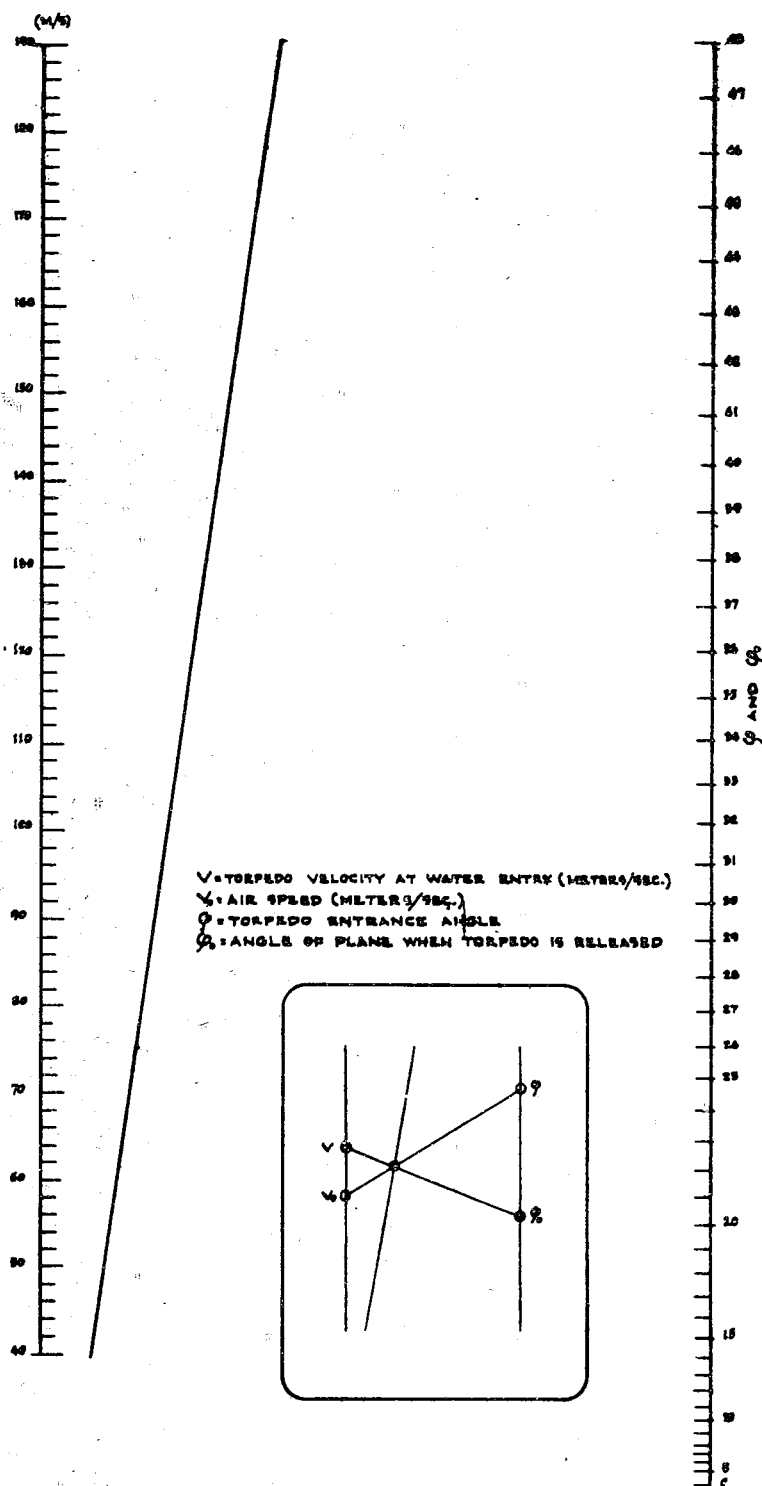


Figure 9
ENTRANCE ANGLE AND VELOCITY CHART
FOR JAPANESE AIRCRAFT TORPEDOES

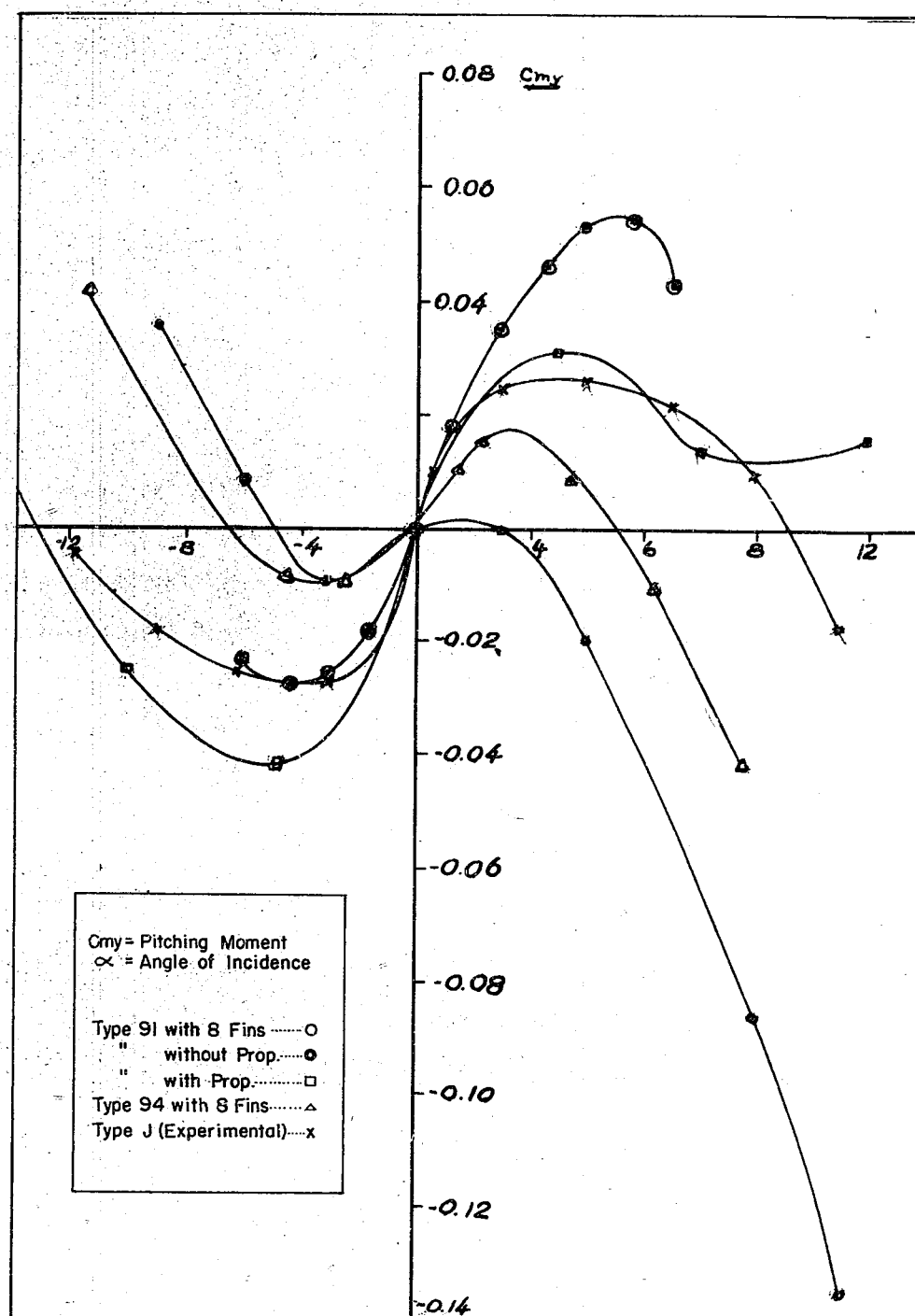


Figure 10
 GRAPH OF PITCHING MOMENT IN AIR
 VS ANGLE OF INCIDENCE FOR VARIOUS TORPEDOES

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funnel-shaped piece is collapsed into a solid conical block by the enormous pressure and propelled forward at an extremely high velocity of about 5000 meters/sec (16,400 ft/sec).

Experiments were made with 1/10 scale models at the Technical Research Institute in TOKYO and with 1/5 and 1/3 scale models in YOKOSUKA. Full size model experiments were conducted at KURE. All tests were made in water against models of multi-layer hulls having water and air spaces.

From the results of experiments, it was found that when the line of impact was normal to the ship's hull, the projectile had the greatest effect. The penetrating power, however, varied with the angle of impact according to the "sine" rule.

Tests were conducted using full size warheads against model hulls similar to COLORADO class battleship hulls. (See NavTechJap Report "Characteristics of Japanese Naval Vessels, Article 9 - Underwater Protection", Index No. S-01-9.) These warheads actually penetrated all compartments of a model hull having the approximate dimensions shown in Figure 11.

The "V"-head was adopted for service in 1944 on the Type 93 and Type 95 torpedoes, and was designated as the Type 6 warhead.

It was first used on aircraft torpedoes in March or April 1945 and was designated as the Type 4 warhead. Commander K. FUKUDA of the First Naval Technical Arsenal near YOKOSUKA, said that three "V"-heads were used on aircraft torpedoes at this time in actual combat. He believed that a U.S. destroyer and a light cruiser were damaged near KUSUNO. This was the only information obtainable on actual service use.

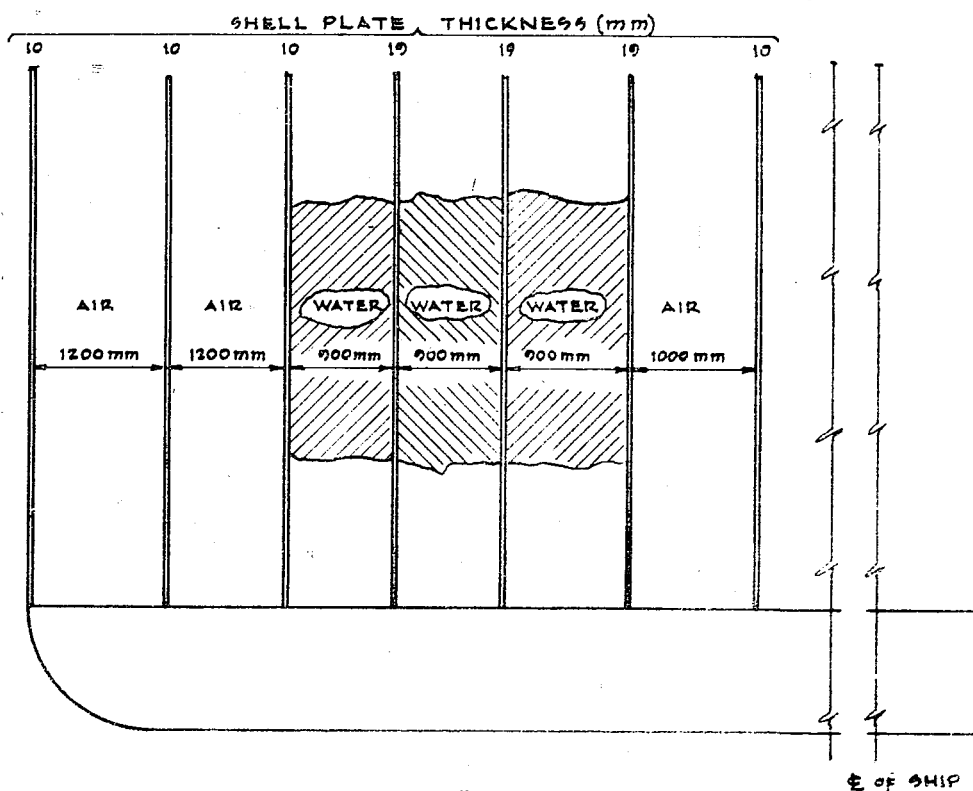


Figure 11

HULL DIAGRAM FOR V-WARHEAD TESTS

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R. Exploders

The Type 90, Model 2; Type 90, Model 2 (strong), and the Type 4 were the only exploders used in aircraft torpedoes.

1. Type 90, Model 2 Exploder

a. General

- (1) Bail, impact type, inertia-firing exploder, fitted transversely in a pocket on top center-line of warhead.
- (2) Used in aircraft torpedoes.

b. Description

(1) External: The exploder is cylindrical in shape, 13.7 inches long, 4.0 inches body diameter, 5.2 inches diameter at top flange and 6.7 inches diameter at top cover. A three-bladed impeller protrudes from the top center of the cover and carries a spring-loaded bail arched over it. Fitted to the bail is a small lug which prevents a rotation of the impeller until the bail is depressed.

(2) Internal: The exploder consists of two main parts as follows:

(a) An upper section 7.8 inches long, which houses:

(i) Arming assembly composed of:

- (aa) The impeller.
- (bb) A reduction gear system.

(ii) Firing assembly composed of:

- (aa) An inertia trigger, which is a brass cup with an elliptical base, shaped to insure displacement when subjected to shock. The trigger is locked before launching by a cylindrical mask, which is lifted when the bail is depressed by water travel.
- (bb) A spring loaded firing spring assembly, centrally located in the lower part of the section and held in the cocked position by two lock detents.

(b) A lower section, housing the detonator, gaine and booster. The gaine is held centrally in the booster, and the booster is aligned with the upper section by a machined ring.

(3) Method of mounting: The exploder is secured in the warhead pocket by a series of bayonet joints between lugs on the exploder flange and corresponding lugs on the retaining ring, which is screwed into the exploder pocket. Aft the pocket is a gear articulating with a rack on the retaining ring. Rotation of this gear within the "Limit-stops" locks or releases the pistol in the pocket.

c. Operation

- (1) Water travel depresses the bail, lifting the mask from the inertia trigger. As the impeller rotates it drives the

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reduction gear system, performing the following arming functions:

- (a) The firing pin is screwed down to the firing position.
- (b) The inertia trigger is unlocked.

(2) Impact displaces the inertia trigger, aligning an escape channel for the two locking detents, which are forced outward by the firing pin as it moves down into the detonator.

2. Type 90 Model 2 (strong)

This was a mass produced and cheapened Type 90.

3. Type 4

This was a further cheapened and simplified Type 90.

S. Exercise Heads

Standard water-blowing type exercise heads were used on all aircraft torpedoes. The heads could be set to blow whenever the torpedo velocity dropped below a certain speed. This method was used in exercise heads for all Japanese torpedoes, and is discussed in detail in NavTechJap Report, "Japanese Torpedoes and Tubes, Article 1 - Ship and Kaiten Torpedoes", Index No. O-01-1.

Part III

JAPANESE EXPERIMENTAL AIRCRAFT TORPEDOES

A. Type 94 Aircraft Torpedo

This was an oxygen torpedo very similar to the Type 95. Its development was stopped in 1935 after about two years of experimentation. It was designed by Technical Rear Admiral S. NARUSE of the First Naval Technical Arsenal, but was very complicated and the handling of oxygen was troublesome. The only advantage in the use of oxygen was for long range, and the Japanese decided that long range was not needed in aircraft torpedoes. Therefore, all production and research were abandoned.

Only about 100-120 were made at YOKOSUKA and NAGASAKI Arsenals before production was stopped.

The general particulars for the Type 94 torpedo are as follows:

| | |
|-------------------------------------|--|
| Diameter | 17.7 in |
| Total length | 208 in |
| Total weight | 1870 lbs |
| Displacement | 1210 lbs |
| Negative buoyancy | 660 lbs |
| Warhead | Same as Type 91, Modif. 1 |
| Weight of Explosive (Type 97) | 330 lbs |
| Exploder | Type 90 (inertia type) |
| Speed | 45 knots |
| Range | 2200 yards |
| Air vessel | Shorter than Type 91 A.V. |
| Water | Used a sea water pump |
| Fuel | Kerosene fed by pressure of the sea water pump |
| Reducer | Same as Type 91 |
| Generator | Wet heater type |
| Engine | 8-cylinder, radial engine same as Type 91 |
| Max. horsepower | 250 |
| Air to fuel ratio | 2.5-2.8 |
| Starting sequence | Same as in Type 93 torpedo |
| Anti-roll stabilizers | None |

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B. Type M Torpedo

This is a 23 inch aircraft torpedo, and was under development from 1942 to 1944. It was planned to use the torpedo with a new, large type of seaplane but the design of the plane was never completed.

The only operational difference from the Type 91 aircraft torpedo, was the use of a semi-internal combustion engine. In an effort to increase the efficiency, experiments were made using a second fuel bottle and injecting a small amount of fuel directly into the cylinders by means of a distributor (See Figures 14 and 15). The distributor rotor was geared to the engine shaft, and the injection was timed as shown in Figure 13. This second fuel was ignited by the hot gases from the combustion chamber, which had already been admitted to the cylinders. The result was an increase in pressure as shown in Figure 13.

No cooling water was used in the torpedo.

Only three Type M torpedoes were made at the First Naval Technical Arsenal, but development did not get beyond the bench test stage.

The main troubles experienced were:

1. Poor ignition of the second fuel.
2. Low air efficiency of 180 B.H.P. per lb of air per second instead of the expected 250-275.
3. Gas leakage through the valves.
4. Difficulties with distributor design.

Because of these difficulties and the halting of the seaplane design, all research on the Type M torpedo was abandoned in 1944.

The principle dimensions can be seen in Figure 17 and Table XV.

C. QR Spiralling Torpedo

This torpedo was developed for use against submarines. The idea was suggested by Rear Admiral S. NARUSE of the First Naval Air Technical Arsenal near YOKOSUKA, and its development was under the supervision of Engineer K. NOMA.

The experimental type letters Q and R were assigned during its development.

1. Construction (See Figure 18): It was a Type 91, Modification 2 aircraft torpedo, with further modifications to make it run in circles and descend at the same time.

The following changes were made to obtain the desired results:

- a. Remove the cover from depth gear.
- b. Blank off the safety valve in the buoyancy chamber.
- c. Run an air pipe from low pressure side of the reducer into the buoyancy chamber and install a 1.0mm diameter nozzle in the chamber end of the pipe.
- d. Set the reducer pressure at 11 kg/cm² (157 psi).
- e. Remove the steering and stabilizer gyro and blank off both of the gyro air leads.
- f. Install a 1.0mm diameter nozzle in the steering air lead so that air is discharged into the afterbody.
- g. Install a safety valve in the afterbody shell to keep the internal air pressure and the sea pressure equalized. The valve is set to operate at a pressure of about 5 psi.
- h. Increase the width of the vertical rudders to 1.40 inches.

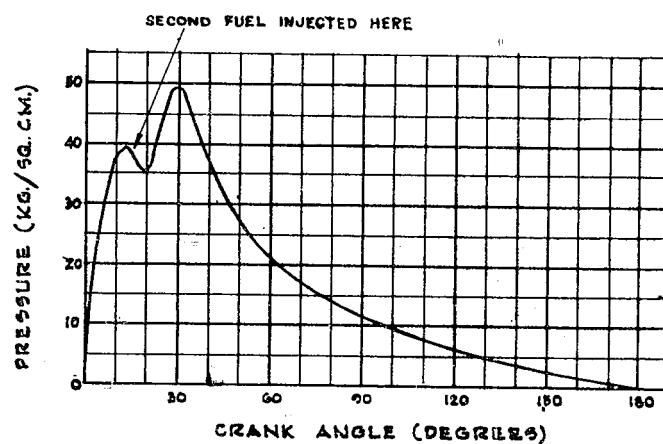


Figure 13
ENGINE DIAGRAM FOR TYPE M TORPEDO

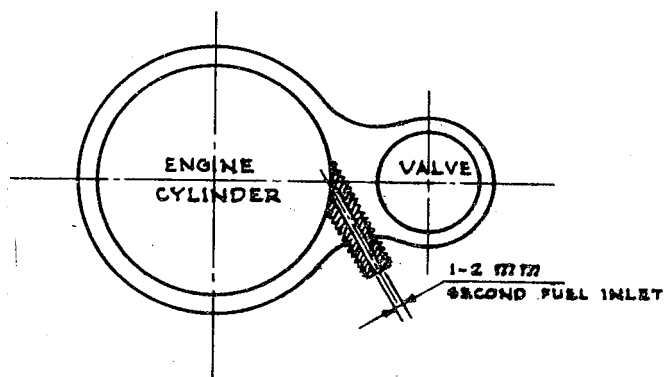


Figure 14
SECOND FUEL INJECTION SYSTEM
FOR TYPE M TORPEDO

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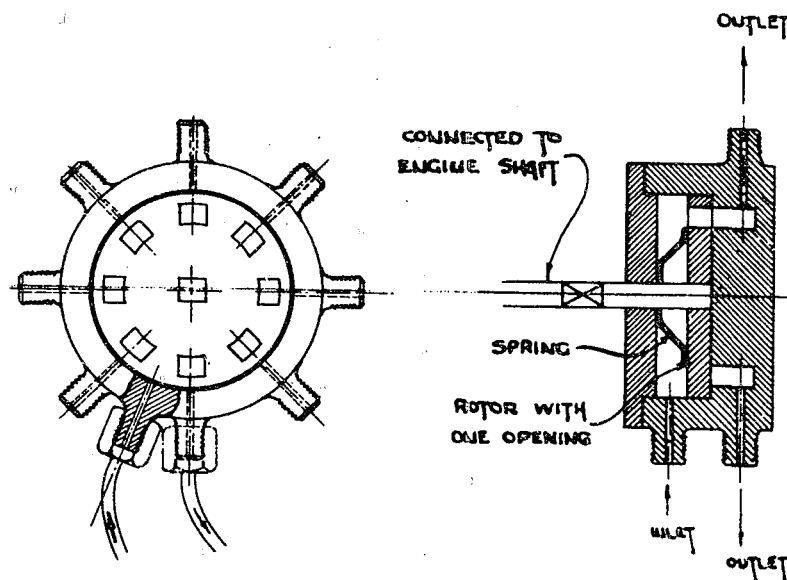


Figure 15
SECOND FUEL DISTRIBUTOR
FOR TYPE M TORPEDO

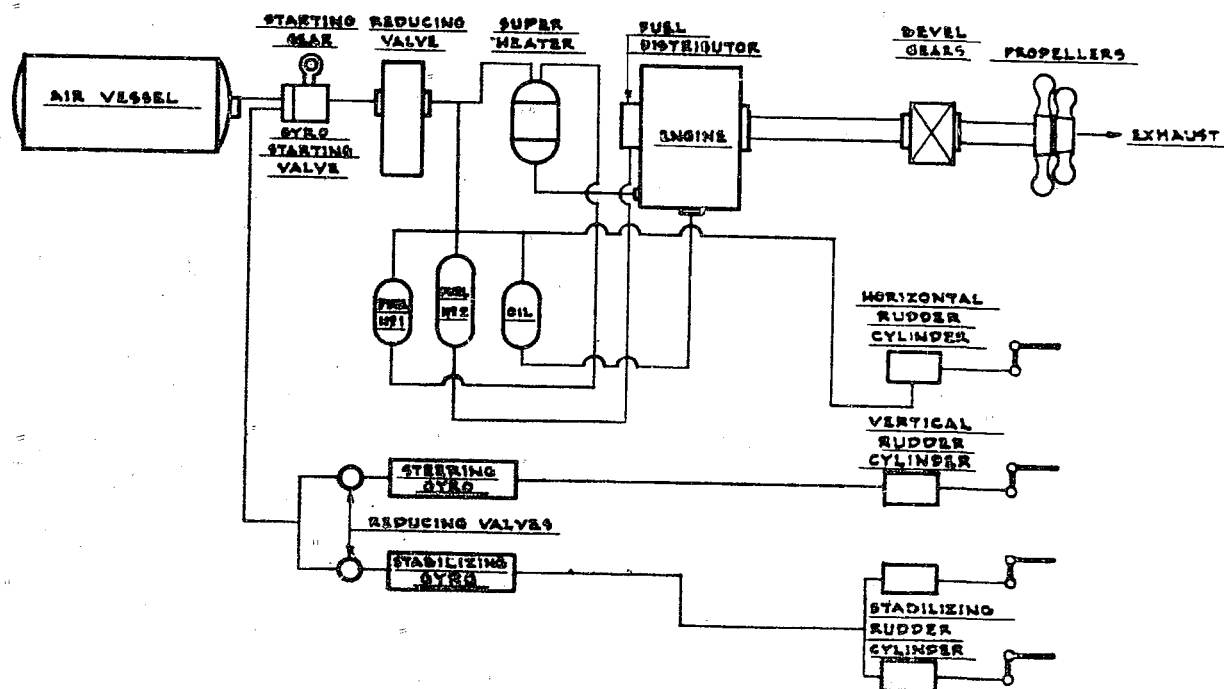


Figure 16
PIPE ARRANGEMENT FOR TYPE M TORPEDO

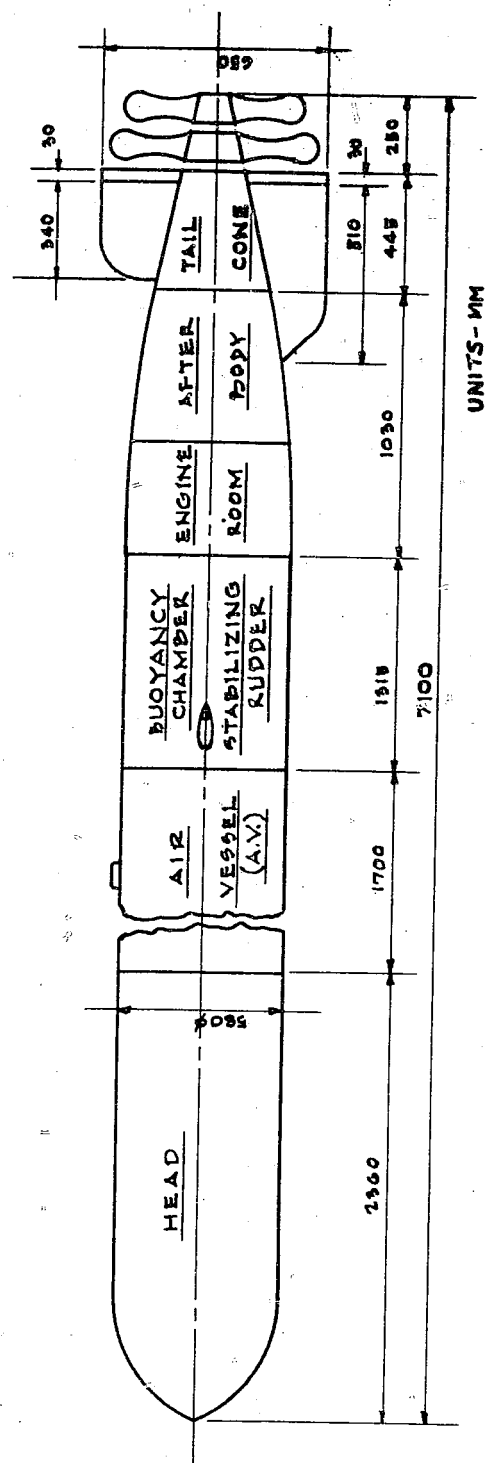


Figure 17
DIMENSIONAL DIAGRAM OF AIRCRAFT
TORPEDO TYPE 'M'

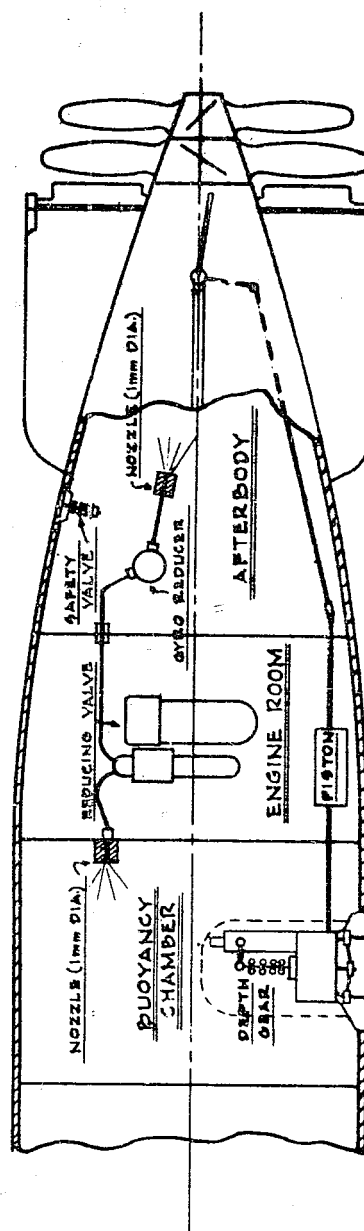


Figure 18
SCHEMATIC DIAGRAM
FOR THE QR SPIRALLING TORPEDO

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Table XV
PRINCIPAL ITEMS OF TORPEDO
Mark M

| | | | | | | | | |
|-----------------------------------|------------------|--------------------|---------|------------------------|------------------------------|-----------|-------------------|-------|
| Warhead | B.C. | kg | 750 | Various Liquid Bottles | Fuel Bottle No. 1 | Volume | lit | 10 |
| | Length | mm | 2360 | | | Thickness | mm | 3.5 |
| | Weight | kg | 1100 | | | | | |
| Total length | | mm | 7100 | | Fuel Bottle No. 2 | Volume | lit | 16 |
| Total width | | mm | 2070 | | | Thickness | mm | 3.5 |
| C.G. from tail end | | mm | 4050 | | | | | |
| Displacement | | kg | 1556 | | Oil bottle | | | |
| Trim | | mm | -190 | | | Volume | lit | 5.5 |
| Negative buoyancy | | kg | 514 | | | | | |
| C.B. from tail end | | mm | 3860 | | | Thickness | mm | 3 |
| Speed | | knots | 50 | Engine | | | | |
| Range | | m | 2500 | | Weight | | kg | 120 |
| Maximum allowable launching speed | | knots | 300 | | Number of cylinders | | | 8 |
| Air Vessel | Air pressure | kg/cm ² | 220 | | Area of cylinder | | cm ² | 122.8 |
| | Volume | lit | 380 | | Bore diameter | | mm | 125 |
| | Weight of air | kg | 96 | | Stroke | | mm | 105 |
| | Thickness | mm | 10 | | Indicator diagram efficiency | | % | 80 |
| | Length | mm | 1700 | | Mechanical efficiency | | % | 85 |
| | Factor of safety | | 1.76 | | Air efficiency | | BHP per kg of air | 550 |
| | Material | | V9,SK,V | | Maximum brake horsepower | | hp | 470 |

1. Fix the vertical rudders at an angle of 10-15 degrees to the right.
2. Operation: When the torpedo is launched, air from the reducer is bled through the nozzle into the buoyancy chamber. Air pressure gradually builds up on top of the uncovered diaphragm in the depth gear at a slightly greater rate than that of the sea pressure. The diaphragm is depressed causing slight down rudder and the torpedo starts to descend in a spiral path.
3. Characteristics: Due to the low reducer pressure, the torpedo's speed was reduced to about 26 knots, but the range was increased to approximately 4000 yards. The diameter of the spiral was about 300 yards with an initial pitch of 20 yards, increasing to about 35 yards at maximum depth. The maximum depth for the torpedo was about 320 feet.
4. Manufacture and Use: At the beginning of 1945, ten QR torpedoes were made at the First Naval Air Technical Arsenal and about forty at the Nagasaki Arsenal. Scarcity of materials halted production.

The Japanese considered the QR torpedo a success as far as technical aspects were concerned, but not enough were made for effective operational use.

Some torpedoes were issued to the service but no information was obtainable on the results of service use.

D. Model 4 Aerial Torpedo:

This is a bomb-torpedo having no propulsion. Its movement through the water depends only on the momentum imparted to it when launched from an airplane.

1. Construction: The torpedo consists of the head and the afterbody. The afterbody has two anti-roll stabilizers similar to those used on the Type 91 aircraft torpedoes, as well as vertical and horizontal fins. The roll stabilizers and vertical rudders are controlled by two separate gyros and servomotors. The air supply comes from a small flask inside the afterbody. The horizontal fin is set at zero degrees, but a small steel triangular box is attached to the top of the fin so that it forms an angle of 30 degrees with the horizontal, and has a height of 100mm (3.49 in) at the trailing edge.

2. Principal Dimensions:

| | |
|---|----------|
| Diameter | 17.7 in |
| Total length | 116.7 in |
| Length of head | 61.5 in |
| Length of afterbody | 55.2 in |
| Total weight | 1100 lbs |
| Weight of explosive (Type 98) | 550 lbs |
| Pull around | 22 lbs |
| Thickness of head shell | 0.157 in |
| Thickness of afterbody shell | 0.130 in |
| Thickness of vertical and horizontal fins | 0.157 in |

3. Detonator: Two detonators are used in this torpedo. A bomb-type fuze is set in the nose, which functions in the case of a direct hit but not upon entering the water. An ordinary Type 90, Model 2 inertia pistol is installed in the middle of the head.

4. Characteristics: The torpedo was developed for use against surface shipping. When launched from a plane with an air speed of 200-300 knots, an altitude of 900-1500 feet and a diving angle of 20-30 degrees, the

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depth of the dive does not exceed 35 feet. Even after a water travel of 300 feet, the velocity is still more than 20 knots.

5. Progress Summary: Between February and October 1943 about forty firing tests were made, using Type 97 carrier based planes and TENZANS (JILL 11).

a. About twenty-five launchings were made under the following conditions:

Altitude 900-1300 feet
Air speed 200-280 knots
Diving angle 20 degrees

The results were poor. Only one-third made good runs at a depth less than thirty feet. One-third made very erratic runs and the rest went down to great depths. The following reasons were given for the poor performance:

- (1) Poor stability due to small L/D ratio of 6.6.
- (2) Inadequate strength of fins.
- (3) Variations in launching conditions.

b. About fifteen level launchings were made at altitudes of 300-500 feet and air speeds of 150-240 knots. Results were comparatively good, with two-thirds making satisfactory runs. The rest ran deep and erratic.

As a result of these tests the Japanese did not consider the torpedo practical enough for service use.

E. Model 6 Anti-Submarine Circling Torpedo

With the exception of a steel nose section to withstand the force of impact, and two small wing braces, the entire torpedo was constructed of wood. It consists of three sections; the head, fuselage, and tail section. Wooden wings run the whole length of the fuselage with a dihedral of 20 degrees. The fuselage was made of laminated wooden sheets and had a total thickness of 15mm (0.59 inches). The wings and rudder were glued to the fuselage and tail section. The rudder was fixed at an angle of eight degrees causing the torpedo to make circles of about 260 feet in diameter. It had no propulsion, and a specific weight of 1.4 which made the torpedo sink in a spiral path having a pitch of about 200 feet.

To prevent the eight degree rudder displacement from affecting the air flight, a wooden fairing was fitted over the rudder. It was held in place by a small aluminum pin which sheared when the torpedo entered the water.

It was planned to use a magnetic proximity fuze, but the development never reached that stage.

1. Principal Dimensions

Total length 116.7 in
Diameter 11.8 in
Total weight 595 lbs
Wing spread 30 in
Weight of explosive (Type 98) 220 lbs
Wing area 10 ft²
Wing load 580 lbs
Thickness of vertical and horizontal fins 1.2 in

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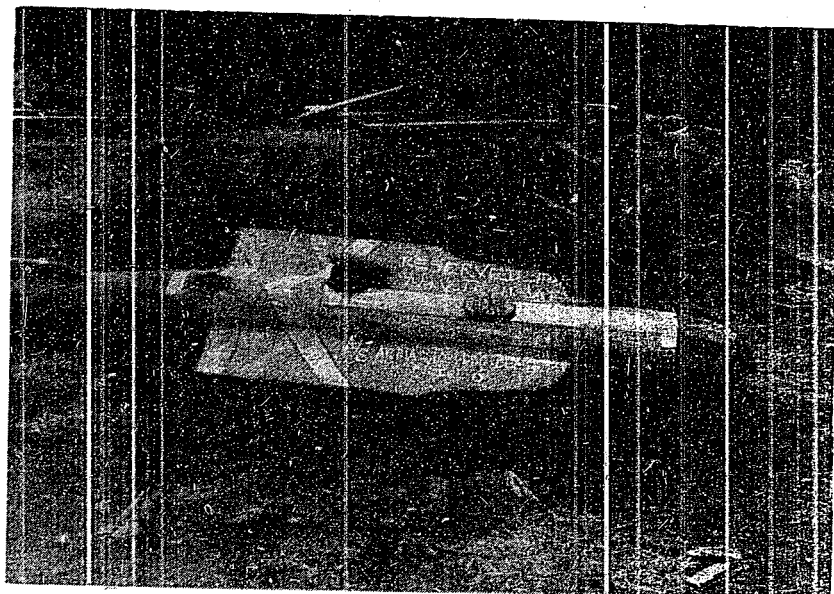


Figure 19
MODEL 6 ANTI-SUBMARINE AERIAL TORPEDO BOMB

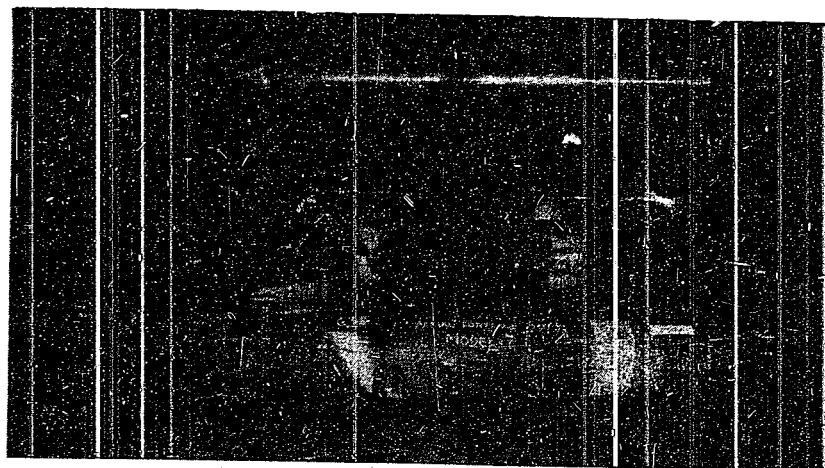


Figure 20
MODEL 7 AERIAL TORPEDO BOMB
WITH WOODEN WINGS REMOVED

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2. Test Results In September 1944, about 40 launchings were made from aircraft with air speeds of about 145 knots and a diving angle of 15-20 degrees. It was found that gliding characteristics were poor and rolling occurred.

Tests were also made on water entry characteristics of the torpedo. On impact the wings were severely damaged and sometimes torn off. In cases where the wings stayed on, the torpedo porpoised severely.

No further experiments were made after 1944.

F. Model 7 Aerial Torpedo

The Model 7 was an anti-submarine circling torpedo similar to the Model 6, but having a steel fuselage and tail section. Wooden wings ran the whole length of the torpedo, from the head joint to the tail fins, with a dihedral angle of 15 degrees. The air gliding speed was about 250 knots at an approximate angle of 20 degrees. The vertical rudder was set at an angle of six degrees and a 30 degree angle board 20mm high fixed on top of the horizontal fin.

1. Principal Dimensions

| | |
|---|--------------------|
| Total length | 116.7 in |
| Diameter | 11.8 in |
| Wing spread | 31.0 in |
| Total weight | 1100 lbs |
| Thickness of fuselage shell | 0.475 in |
| Explosive charge | 485 lbs |
| Wing area | 17 ft ² |
| Wing load | 690 lbs |
| Thickness of vertical and horizontal fins | 0.98 in |

2. Test Results: Underwater travel tests were not made, but it was expected to describe a spiral path similar to the Model 6 aerial torpedo bomb and with approximately the same velocity.

In January 1945 eleven gliding tests were made using an air speed of 220 knots, altitude of 1000 feet and a diving angle of 15 degrees. The lateral stability was poor and excessive rolling occurred in all cases.

It was definitely decided that anti-roll stabilizers should be installed, but no further tests were made with the Model 7 aerial torpedo.

G. Model 8 Aerial Torpedo

After many efforts to obtain a successful bomb torpedo, the Model 8 finally achieved some degree of success just before the end of the war.

It was similar to the Model 4 in design and operation, and differed from it only in the following points:

- The L/D ratio was increased from 6.6 to 11 with a resulting increase in stability.
- The thickness of the head shell was increased from 0.157 inches to 0.473 inches to improve its penetrating ability.
- The vertical and horizontal tail fins were strengthened to withstand the impact of water entry.
- The height of the 30 degree angle box fixed to the top of the horizontal fin was changed from 100mm (0.394 in) to 70mm (0.275 in).

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1. Principal Dimensions

| | |
|---|----------|
| Diameter | 11.8 in |
| Total length | 130.0 in |
| Length of head | 69.3 in |
| Length of afterbody | 60.7 in |
| Total weight | 1100 lbs |
| Weight of explosive | 352 lbs |
| Pull around | 4.4 lbs |
| Thickness of head shell | 0.473 in |
| Thickness of afterbody shell | 0.130 in |
| Thickness of vertical and horizontal fins | 0.157 in |

2. Detonator: Same as in Model 4 aerial torpedo bomb.

3. Test Results: In July 1945 six launching tests were made from a plane with air speeds of 200-250 knots, altitudes of 60-350 feet, and angles of 0-15 degrees.

The results were good and all torpedoes stayed within a depth of 35 feet, and had a minimum velocity of 25 knots after 230 feet of water travel. No further experiments were made before the war ended a few weeks later.

H. Rocket and Jet Torpedoes

In 1941 the Japanese experimented with jet-propelled aircraft torpedoes. The engine was removed from a Type 91, Modification 3 torpedo and the gases from the combustion chamber were ejected through a nozzle in the tail. Kerosene was used as fuel, and burned in the same manner as in ordinary aircraft torpedoes. This was the Type 1 torpedo and only four of them were made for experimental purposes. It had a maximum range of 320 yards with a speed of 30 knots. Difficulties were found with unsteady combustion and poor depth control. All experiments were discontinued after three months.

In 1944, efforts were made to develop a rocket torpedo using tetra-nitromethane and methyl alcohol for fuel. Laboratory tests were made on the combustion of this fuel and it was found that ordinary igniters did not develop enough heat to start combustion. Experiments were made igniting kerosene in the chamber first, and then injecting other fuels afterwards. It was designated as a KR torpedo, but all experiments were unsuccessful and were abandoned a few months later.

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ENCLOSURE (A)

PRODUCTION AND COST FIGURES
FOR
JAPANESE AIRCRAFT TORPEDOES AND MINES

EMPLOYMENT IN ORDNANCE PLANTS

| | Year | Size of Plant | Number of Plants | Total Workers | Total Hours Worked | Total Wage Bill |
|-------------------------------|------|-------------------|----------------------------------|---------------|--------------------|-----------------|
| Aircraft Torpedo | 1941 | Over 1000 workers | 1 (Nagasaki) | 1800 | 5,400,000 | 5,400,000 |
| | | 100-1000 workers | 1 (Yokosuka) | 400 | 1,200,000 | 1,200,000 |
| | | Under 100 workers | | | | |
| | 1942 | Over 1000 workers | 1 (Nagasaki) | 4600 | 13,800,000 | 13,800,000 |
| | | 100-1000 workers | 1 (Yokosuka) | 400 | 1,200,000 | 1,200,000 |
| | | Under 100 workers | | | | |
| | 1943 | Over 1000 workers | 2 (Nagasaki & Hikari) | 6900 | 20,700,000 | 20,700,000 |
| | | 100-1000 workers | 4 (Y, Kure, Kawatana, & Mizuru) | 2150 | 6,450,000 | 6,450,000 |
| | | Under 100 workers | | | | |
| | 1944 | Over 1000 workers | 3 (Nagasaki, Kawatana, & Hikari) | 25000 | 75,000,000 | 75,000,000 |
| | | 100-1000 workers | | | | |
| Aircraft Mine Type 3, No. I | 1943 | Over 1000 workers | 2 (Nagasaki & Kawatana) | 18200 | 54,600,000 | 54,600,000 |
| | 1943 | 100-1000 workers | 2 | 1400 | 2,350,000 | 2,350,000 |
| | 1944 | 100-1000 workers | 3 | 2640 | 7,920,000 | 7,920,000 |
| Aircraft Mine Type 3, No. II | 1945 | 100-1000 workers | 2 | 1600 | 800,000 | 800,000 |
| | 1943 | 100-1000 workers | 1 | 560 | 420,000 | 420,000 |
| | 1944 | 100-1000 workers | 5 | 860 | 2,580,000 | 2,580,000 |
| Aircraft Mine Type 3, No. III | 1945 | 100-1000 workers | 4 | 560 | 560,000 | 560,000 |
| | 1944 | 100-1000 workers | 2 | 700 | 1,225,000 | 1,225,000 |

REQUISITE TIME FROM RAW MATERIALS TO COMPLETE ORDNANCE

A.T. Type 91 5000 hours
A.M. Type 3, No. I 1200 hours
A.M. Type 3, No. II 500 hours
A.M. Type 3, No. III 2500 hours

ENCLOSURE (A), continued

ORDNANCE STOCKS IN ARSENALS AND FACTORIES
CONTROLLED BY NAVY
(Yen Value)

| | Category | March 1941 | March 1942 | March 1943 | March 1944 | March 1945 |
|--------------------------------|---------------------|------------|------------|------------|------------|------------|
| Aircraft Torpedoes | Finished Products | 3,525,000 | 1,620,000 | 1,500,000 | 2,696,500 | 2,082,500 |
| | Finished Components | 750,000 | 1,522,500 | 2,625,000 | 11,418,000 | 7,962,500 |
| | Work in Progress | 1,250,000 | 220,950 | 3,285,900 | 11,649,750 | 9,555,000 |
| | Raw Material | 525,000 | 975,000 | 2,450,000 | 7,035,000 | 4,655,000 |
| | TOTAL | 6,050,000 | 4,338,450 | 9,860,900 | 32,797,250 | 24,255,000 |
| Aircraft Mine Type 3, No I | Finished Products | | | | 1,137,500 | 2,145,000 |
| | Finished Components | | | | 2,762,500 | 1,950,000 |
| | Work in Progress | | | | 3,315,000 | 2,340,000 |
| | Raw Material | | | | 1,657,500 | 1,170,000 |
| | TOTAL | | | | 8,872,500 | 7,609,000 |
| Aircraft Mine Type 3, No II | Finished Products | | | | 360,000 | 868,000 |
| | Finished Components | | | | 720,000 | 1,008,000 |
| | Work in Progress | | | | 864,000 | 1,209,600 |
| | Raw Material | | | | 432,000 | 604,800 |
| | TOTAL | | | | 2,376,000 | 3,690,400 |

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ENCLOSURE (A), continued

EFFECT OF AIR ATTACKS
(AIRCRAFT TORPEDO AND AIRCRAFT MINE)
Data for 1945

| Name of Plants | Date of Air Attack | Capacity (%) | | Output | | Physical Damage (%) | Inventory Loss (Yen) | Capacity after Recovery | Terms for Recovery |
|------------------------------------|--------------------|--------------|-------|--------|-------|---------------------|----------------------|-------------------------|--------------------|
| | | Before | After | Before | After | | | | |
| Nagasaki Arsenal | 9 Aug. 1945 | 100 | 0 | 120 | 0 | almost 100 | Unknown | Nothing | Nonrecovery |
| Isomura Products Co. Ltd. | 24 May 1945 | 100 | 0 | 40 | 0 | 100 | Unknown | Nothing | Dispersion |
| Ozaki Mfg. Co. Ltd. | 10 Mar. 1945 | 100 | 0 | 80 | 0 | 100 | Unknown | Nothing | Production stop |
| Saito Centrifugal Machine Co. Ltd. | 14 May 1945 | 100 | 0 | 50 | 0 | 100 | Unknown | Nothing | Production stop |
| Tokyo Electric Co. Ltd. | 25 May 1945 | 100 | 80 | 30 | 20 | 20 | Unknown | 80 | |
| Morita Pump Mfg. Co. | 1 June 1945 | 100 | 0 | 40 | 0 | 100 | Unknown | Nothing | Production stop |

ENCLOSURE (A), continued

PLANS FOR DISPERSION
Annual Data 1944 - 1945

| | Plan of Dispersion | | | | Execution of Dispersion | | | | |
|------------------|--------------------|-------------|----------|-----|-------------------------|----------|-----|----------|-----|
| | Before | After | | | | 1944 | | 1945 | |
| | Capacity | Division | Capacity | | Division | Capacity | | Capacity | |
| Aircraft Torpedo | 450 | Overground | 200 | 450 | Overground | 450 | 20 | 450 | 140 |
| | Kawadena 200 | Underground | 130 | | Underground | | 70 | | 130 |
| | | Mainland | 0 | | Mainland | | | | |
| | Nagasaki 250 | Maintenance | 120 | | Maintenance | | 360 | | 180 |
| | | | | | | | | | |
| Aircraft Mine | 640 | Overground | 215 | 640 | Overground | 330 | | 640 | 60 |
| | | Underground | 50 | | Underground | | | | 10 |
| | | Mainland | 0 | | Mainland | | | | |
| | | Maintenance | 375 | | Maintenance | | 330 | | 570 |
| | | | | | | | | | |

ORDNANCE PRODUCTION PLANS
Annual Data 1931 - 1940

| Items | 1931 | 1932 | 1933 | 1934 | 1935 | 1936 | 1937 | 1938 | 1939 | 1940 |
|----------------------|------|------|------|------|------|------|------|------|------|------|
| A.T. Type 91, Mod I | 10 | 50 | 100 | 150 | 200 | 250 | 300 | 300 | 300 | 450 |
| A.T. Type 94, Mod I | | | | | | | | 5 | 35 | 25 |
| A.T. Type 94, Mod II | | | | | | | | 70 | 130 | |

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ENCLOSURE (A), continued

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ORDNANCE PRODUCTION PLANS
Monthly Data 1941 - 1945

| Item | Date of Plan | April | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. | Jan. | Feb. | March | Total Year |
|-------------------------------|--------------|-------|-----|------|------|------|-------|------|------|------|------|------|-------|------------|
| 1941 A.T. Type 91, Mod II | Dec. 1940 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 60 |
| A.T. Type 91, Mod II | Feb. 1941 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | | | | | | 320 |
| A.T. Type 91, Mod III | Aug. 1941 | | | | | | | | | 50 | 70 | 100 | 100 | 320 |
| 1942 A.T. Type 91, Mod III | Dec. 1941 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 60 |
| A.T. Type 91, Mod III | Feb. 1942 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 1200 |
| A.T. Type 91, Mod III | Feb. 1942 | 100 | 100 | 100 | 110 | 115 | 120 | 190 | 185 | 215 | 215 | 245 | 235 | 1930 |
| 1943 A.T. Type 91, Mod III | Dec. 1942 | 5 | 7 | 8 | 10 | 10 | 10 | 10 | 15 | 15 | 20 | 20 | 20 | 150 |
| A.M. Type 3, No. I | June 1943 | | | | | 20 | 30 | 100 | 150 | 250 | 250 | 250 | 250 | 1300 |
| A.M. Type 3, No. II | Nov. 1943 | | | | | | | | | | 100 | 200 | | 300 |
| 1944 A.T. Type 91, Mod II | Dec. 1943 | 280 | 320 | 350 | 390 | 440 | 430 | 440 | 420 | 490 | 475 | 445 | 465 | 4940 |
| A.T. Type 4 | Dec. 1943 | | | 10 | 10 | 10 | 20 | 30 | 50 | 60 | 100 | 130 | 140 | 560 |
| A.M. Type 3, No. I | Dec. 1943 | 175 | 175 | 175 | 325 | 345 | 365 | 395 | 405 | 425 | 425 | 425 | 425 | 4060 |
| A.M. Type 3, No. II | Jan. 1944 | 325 | 325 | 325 | 325 | 355 | 385 | 405 | 455 | 525 | 525 | 525 | 525 | 4970 |
| A.M. Type 3, No. III | Jan. 1944 | 50 | 50 | 50 | 50 | 50 | 50 | | | | | | | 300 |
| 1945 A.T. Type 91, Mod III | Dec. 1944 | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 1800 |
| A.T. Type 4 | Dec. 1944 | 250 | 250 | 250 | 250 | 300 | 300 | 300 | 300 | 350 | 350 | 400 | 400 | 3700 |
| A.M. Type 3, No. I | Dec. 1944 | 300 | 300 | | | | | | | | | | | 600 |
| A.M. Type 3, No. II | Dec. 1944 | 360 | 360 | 360 | 360 | 360 | 360 | | | | | | | 2160 |

ENCLOSURE (A), continued

ORDNANCE PRODUCTION
Annual Data 1931 - 1945
(Yen Value*)

| Item | 1931 | 1932 | 1933 | 1934 | 1935 | 1936 | 1937 | 1938 | 1939 | 1940 | 1941 | 1942 | 1943 | 1944 | 1945 |
|-----------------------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
| A.T. Type 91, Mod I | 7 | 53 | 702 | 150 | 193 | 237 | 308 | 312 | 280 | 450 | | | | | |
| A.T. Type 91, Mod II | | | | | | | | | | | 237 | | | | |
| A.T. Type 91, Mod III | | | | | | | | | | | 473 | 1200 | 1800 | 3565 | 297 |
| A.T. Type 4 | | | | | | | | | | | | | | 328 | 552 |
| A.T. Type 94, Mod I | | | | | | | | 5 | 32 | 21 | | | | | |
| A.T. Type 94, Mod II | | | | | | | | 62 | 138 | | | | | | |
| A.M. Type 3, No 1 | | | | | | | | | | | | | | | |
| A.M. Type 3, No 2 | | | | | | | | | | | | | 530 | 2500 | 283 |
| A.M. Type 3, No 3 | | | | | | | | | | | | | | 1990 | 430 |
| | | | | | | | | | | | | | | 250 | |

ORDNANCE PRODUCTION
Annual Data 1931 - 1945
(Number of Units)

| Item | 1931 | 1932 | 1933 | 1934 | 1935 | 1936 | 1936 | 1938 | 1939 | 1940 | 1941 | 1942 | 1943 | 1944 | 1945 |
|-----------------------|------|------|------|------|------|------|------|------|------|------|------|-------|-------|-------|-------|
| A.T. Type 91, Mod I | 105 | 785 | 153 | 225 | 2895 | 3555 | 4620 | 4680 | 4200 | 6750 | | | | | |
| A.T. Type 91, Mod II | | | | | | | | | | | 3695 | | | | |
| A.T. Type 91, Mod III | | | | | | | | | | | 7110 | 18195 | 31950 | 88735 | 8039 |
| A.T. Type 4 | | | | | | | | | | | | | | 3431 | 7170 |
| A.T. Type 94, Mod I | | | | | | | | 175 | 1120 | 735 | | | | | |
| A.T. Type 94, Mod II | | | | | | | | 1860 | 4140 | | | | | | |
| A.M. Type 3, No I | | | | | | | | | | | | | | | |
| A.M. Type 3, No II | | | | | | | | | | | | | 3575 | 16250 | 18395 |
| A.M. Type 3, No III | | | | | | | | | | | | | 540 | 2502 | 1204 |
| | | | | | | | | | | | | | | 20875 | |

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ENCLOSURE (A), continued

ORDNANCE PRODUCTION
Monthly Data 1941 - 1945
(Yen Value*)

| | April | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. | Jan. | Feb. | March | Total Year |
|-------------------------------|--------|-------|--------|--------|--------|--------|-------|------|--------|------|------|--------|------------|
| 1941 A.T. Type 91 Mod. II | 360 | 420 | 595 | 460 | 610 | 480 | 270 | 500 | | | | | 3695 |
| 1942 A.T. Type 91 Mod. III | | | | | | | 145 | 350 | 1120 | 1960 | 990 | 2545 | 7110 |
| 1943 A.T. Type 91 Mod. III | 985 | 1275 | 2675 | 1285 | 1615 | 1685 | 1305 | 2525 | 1875 | 1390 | 815 | 1825 | 18195 |
| 1944 A.T. Type 91 Mod. III | 1365 | 1296 | 1215 | 1552 | 1691 | 2060 | 2222 | 3153 | 2709 | 2956 | 3752 | 6679 | 31950 |
| A.M. Type 3 No. I | | | | | | 162.5 | 325 | 325 | 325 | 975 | 995 | 1789.5 | 4975 |
| A.M. Type 3 No. II | | | | | | | | | | | 180 | 360 | 540 |
| A.T. Type 91 Mod. III | 6568 | 9284 | 7629 | 8319 | 8809 | 9375 | 9098 | 9157 | 8141 | 6871 | 4193 | 3298 | 88729 |
| 1945 A.T. Type 4 | | | | | | | | | 662 | 1490 | 1291 | 1987 | 4089 |
| A.M. Type 3 No. I | 1137.5 | 325 | 1462.5 | 1139.5 | 1039 | 1170 | 1235 | 1300 | 1332.5 | 1830 | 2145 | 2145 | 16250 |
| A.M. Type 3 No. II | | | | 36 | 99 | 135 | 180 | 225 | 360 | 405 | 477 | 558 | 2492 |
| A.M. Type 3 No. III | 417.5 | | | 417.5 | 417.46 | 417.46 | 417.5 | | | | | | 2087.42 |
| A.T. Type 91 Mod. III | 3418 | 1418 | 1452 | 2100 | | | | | | | | | 8074 |
| A.T. Type 4 | 1656 | 2765 | 2748 | 1980 | | | | | | | | | 11094 |
| A.M. Type 3 No. I | 1300 | 539.5 | | | | | | | | | | | 1839.5 |
| A.M. Type 3 No. II | 476 | 196 | 252 | 280 | | | | | | | | | 1204 |

*Units 1000 yen.

ENCLOSURE (A), continued

ORDNANCE PRODUCTION
Monthly Data 1941 - 1945
(Number of Units)

| | April | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. | Jan. | Feb. | March | Total Year |
|-------------------------------|-------|-----|------|------|------|-------|------|------|------|------|------|-------|------------|
| 1941 A.T. Type 91 Mod. II | 22 | 27 | 38 | 29 | 40 | 31 | 17 | 33 | | | | | 237 |
| 1942 A.T. Type 91 Mod. III | | | | | | | 9 | 22 | 72 | 128 | 64 | 168 | 473 |
| 1943 A.T. Type 91 Mod. III | 60 | 84 | 177 | 85 | 107 | 112 | 86 | 101 | 124 | 91 | 53 | 120 | 1200 |
| 1944 A.T. Type 91 Mod. III | 89 | 84 | 79 | 98 | 103 | 125 | 129 | 184 | 135 | 158 | 270 | 340 | 1800 |
| 1945 A.M. Type 3 No. I | | | | | | 25 | 50 | 50 | 50 | 100 | 100 | 175 | 550 |
| 1946 A.T. Type 91 Mod. III | 293 | 315 | 321 | 337 | 311 | 302 | 390 | 394 | 330 | 261 | 204 | 149 | 3565 |
| 1947 A.T. Type 4 | | | | | | | | | 40 | 90 | 78 | 120 | 328 |
| 1948 A.M. Type 3 No. I | 175 | 50 | 225 | 175 | 160 | 180 | 190 | 200 | 205 | 280 | 330 | 330 | 2500 |
| 1949 A.M. Type 3 No. II | | | | 20 | 50 | 75 | 100 | 140 | 200 | 225 | 265 | 310 | 1390 |
| 1950 A.M. Type 3 No. III | 50 | | | 50 | 50 | 50 | 50 | | | | | | 250 |
| 1951 A.T. Type 91 Mod. III | 144 | 48 | 45 | 60 | | | | | | | | | 297 |
| 1952 A.T. Type 4 | 100 | 167 | 165 | 120 | | | | | | | | | 552 |
| 1953 A.M. Type 3 No. I | 200 | 83 | | | | | | | | | | | 283 |
| 1954 A.M. Type 3 No. II | 170 | 70 | 90 | 100 | | | | | | | | | 430 |

RESTRICTED

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ENCLOSURE (A), continued

ORDNANCE PRODUCTION BY INDIVIDUAL PLANTS
(Yen Value*)

| | Year | April | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. | Jan. | Feb. | March | Total Year |
|------------------|----------------------|-------|-----|------|------|------|-------|------|------|------|------|------|-------|------------|
| Nagasaki Arsenal | A.T. Type 91 Mod II | 1941 | | | | | | | | | | | | |
| | A.T. Type 91 Mod III | 1941 | | | | | | | | | | | | |
| | A.T. Type 91 Mod III | 1942 | | | | | | | | | | | | |
| | A.T. Type 91 Mod III | 1943 | | | | | | | | | | | | |
| | A.T. Type 91 Mod III | 1944 | | | | | | | | | | | | |
| | A.T. Type 4 | 1944 | | | | | | | | | | | | |
| | A.T. Type 91 Mod III | 1945 | | | | | | | | | | | | |
| Yokosuka Arsenal | A.T. Type 4 | 1945 | | | | | | | | | | | | |
| | A.T. Type 91 Mod II | 1941 | | | | | | | | | | | | |
| | A.T. Type 91 Mod III | 1941 | | | | | | | | | | | | |
| | A.T. Type 91 Mod III | 1942 | | | | | | | | | | | | |
| | A.T. Type 91 Mod III | 1943 | | | | | | | | | | | | |
| | A.T. Type 91 Mod III | 1944 | | | | | | | | | | | | |
| | A.T. Type 91 Mod III | 1945 | | | | | | | | | | | | |
| Kure Arsenal | A.T. Type 91 Mod III | 1943 | | | | | | | | | | | | |
| Hikari Arsenal | A.T. Type 91 Mod III | 1943 | | | | | | | | | | | | |
| Isomura Products | A.M. Type 3 No. II | 1944 | | | | | | | | | | | | |
| | A.M. Type 3 No. II | 1945 | | | | | | | | | | | | |
| Ozaki Mfg. Co. | A.M. Type 3 No. II | 1944 | | | | | | | | | | | | |

*Units 1000 yen.

ENCLOSURE (A), continued

ORDNANCE PRODUCTION BY INDIVIDUAL PLANTS (Cont.)
(Yen Value*)

| | Year | April | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. | Jan. | Feb. | March | Total Year |
|---------------------------------|----------------------|-------|--------|-------|--------|-------|--------|--------|------|-------|------|------|--------|------------|
| Nisigata Yoki | A.M. Type 3 No. II | 1944 | | | | 18 | 18 | 36 | 54 | 54 | 54 | 90 | 108 | 432 |
| | A.M. Type 3 No. II | 1945 | 140 | 140 | 196 | 224 | | | | | | | | 700 |
| Toko Electric Co. | A.M. Type 3 No. II | 1944 | | | | | | | | | 27 | 45 | 54 | 126 |
| | A.M. Type 3 No. II | 1945 | 34 | 56 | 56 | 56 | | | | | | | | 252 |
| Ishikawa Mfg. Co. | A.M. Type 3 No. I | 1944 | | | | 325 | 650 | 975 | 975 | 975 | 975 | 975 | 975 | 7800 |
| | A.M. Type 3 No. I | 1945 | 650 | 214.5 | | | | | | | | | | 864.5 |
| Morita Pump Co. | A.M. Type 3 No. I | 1944 | | | | | 64 | 195 | 195 | 195 | 260 | 260 | 260 | 1625 |
| | A.M. Type 3 No. I | 1944 | | | | | | 65 | 130 | 162.5 | 260 | 260 | 260 | 1137.5 |
| 21st Aerial Arsenal | A.M. Type 3 No. I | 1943 | | | | | | | | | 325 | 325 | 650 | 1300 |
| | A.M. Type 3 No. I | 1944 | 1137.5 | 325 | 1462.5 | 812.5 | 325 | 0 | 0 | 0 | 325 | 650 | 650 | 5687.5 |
| Osaka Machinery Co. | A.M. Type 3 No. I | 1945 | 650 | 325 | | | | | | | | | | 975 |
| | A.M. Type 3 No. III | 1944 | | | | 18 | 36 | 36 | 54 | 90 | 90 | 90 | 90 | 504 |
| Saito Centrifugal Machinery Co. | A.M. Type 3 No. III | 1945 | 140 | | | | | | | | | | | 140 |
| | A.M. Type 3 No. III | 1944 | | | | 417.5 | 208.75 | 417.5 | | | | | | 1252.5 |
| Aichi Doka | A.T. Type 91 Mod III | 1943 | | | | | | 260 | 0 | 260 | 0 | 0 | 260 | 780 |
| | A.M. Type 3 No. I | 1943 | | | | | 162.5 | 325 | 325 | 325 | 650 | 650 | 1137.5 | 3675 |
| Maizuru Arsenal | A.M. Type 3 No. II | 1943 | | | | | | | | | | 180 | 360 | 540 |
| | A.M. Type 3 No. III | 1944 | 417.5 | 0 | 0 | 0 | 208.75 | 208.75 | | | | | | 834.92 |

RESTRICTED

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ENCLOSURE (A), continued

ORDNANCE PRODUCTION BY INDIVIDUAL PLANTS (Cont.)
(Number of Units)

| | Year | April | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. | Jan. | Feb. | March | Total Year |
|-------------------|---------------------------|-------|-----|------|------|------|-------|------|------|------|------|------|-------|------------|
| Nagasaki Arsenal | A.T. Type 91 Mod II 1941 | 16 | 24 | 33 | 24 | 38 | 28 | 14 | 32 | | | | | 209 |
| | A.T. Type 91 Mod III 1941 | | | | | | | 7 | 18 | 64 | 120 | 58 | 163 | 430 |
| | A.T. Type 91 Mod III 1942 | 55 | 81 | 173 | 83 | 105 | 111 | 83 | 99 | 121 | 86 | 49 | 115 | 1161 |
| | A.T. Type 91 Mod III 1943 | 84 | 78 | 74 | 81 | 80 | 100 | 97 | 151 | 79 | 100 | 178 | 228 | 1330 |
| | A.T. Type 91 Mod III 1944 | 180 | 203 | 194 | 212 | 180 | 185 | 202 | 208 | 180 | 114 | 167 | 107 | 2132 |
| | A.T. Type 4 1944 | | | | | | | | | 40 | 90 | 78 | 120 | 328 |
| Yokosuka Arsenal | A.T. Type 91 Mod II 1945 | 91 | 15 | 5 | | | | | | | | | | 111 |
| | A.T. Type 4 1945 | 100 | 167 | 166 | 120 | | | | | | | | | 553 |
| | A.T. Type 91 Mod II 1941 | 6 | 3 | 5 | 5 | 2 | 3 | 3 | | | | | | 28 |
| | A.T. Type 91 Mod II 1941 | | | | | | | 2 | 4 | 8 | 3 | 6 | 5 | 33 |
| | A.T. Type 91 Mod II 1942 | 5 | 3 | 4 | 2 | 2 | 1 | 3 | 2 | 3 | 5 | 4 | 5 | 39 |
| | A.T. Type 91 Mod II 1943 | 5 | 6 | 5 | 7 | 8 | 10 | 7 | 8 | 10 | 16 | 15 | 21 | 118 |
| Kawadana Arsenal | A.T. Type 91 Mod II 1944 | 26 | | | | | | | | | | | | 26 |
| | A.T. Type 91 Mod III 1943 | | | | | 3 | 0 | 0 | 5 | 15 | 12 | 18 | 20 | 73 |
| | A.T. Type 91 Mod III 1944 | 29 | 45 | 52 | 60 | 80 | 100 | 58 | 64 | 60 | 55 | 36 | 40 | 679 |
| | A.T. Type 91 Mod III 1945 | 52 | 33 | 39 | 60 | | | | | | | | | 174 |
| | A.T. Type 91 Mod III 1943 | | | | 10 | 12 | 10 | 10 | 15 | 11 | 20 | 27 | 22 | 137 |
| | A.T. Type 91 Mod III 1943 | | | | | | 5 | 5 | 5 | 10 | 10 | 32 | 45 | 112 |
| Hikari Arsenal | A.T. Type 91 Mod III 1944 | 58 | 67 | 75 | 78 | 89 | 82 | 110 | 102 | 90 | 92 | | | 843 |
| | A.T. Type 91 Mod III 1943 | | | | | | | 10 | 0 | 10 | 0 | 0 | 10 | 30 |
| Matsuyama Arsenal | A.M. Type 3 No. I 1943 | | | | | | 25 | 50 | 50 | 50 | 50 | 50 | 75 | 350 |
| | A.M. Type 3 No. II 1943 | | | | | | | | | | | 100 | 200 | 300 |
| | A.M. Type 3 No. III 1944 | 50 | 0 | 0 | 0 | 25 | 25 | | | | | | | 100 |
| | A.M. Type 3 No. III 1944 | | | | | | | | | | | | | |

RESTRICTED

ENCLOSURE (A), continued

ORDNANCE PRODUCTION BY INDIVIDUAL PLANTS (Cont.)
(Number of Units)

| | Year | April | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. | Jan. | Feb. | March | Total Year |
|---------------------------------|---------------------|-------|-----|------|------|------|-------|------|------|------|------|------|-------|------------|
| Osaka Machinery Co. | A.M. Type 3 No. I | 1943 | | | | | | | | | 50 | 50 | 100 | 200 |
| | A.M. Type 3 No. I | 1944 | 175 | 50 | 225 | 125 | 50 | | | | 50 | 100 | 100 | 875 |
| | A.M. Type 3 No. I | 1945 | 100 | 50 | | | | | | | | | | 150 |
| 21st Aerial Arsenal | A.M. Type 3 No. I | 1944 | | | | | | 10 | 20 | 25 | 40 | 40 | 40 | 175 |
| | A.M. Type 3 No. I | 1944 | | | | 50 | 100 | 150 | 150 | 150 | 150 | 150 | 150 | 1200 |
| Ishikawa Mfg. Co. | A.M. Type 3 No. I | 1944 | | | | | | | | | | | | 133 |
| | A.M. Type 3 No. I | 1945 | 100 | 33 | | | | | | | | | | 250 |
| Morita Pump Co. | A.M. Type 3 No. I | 1944 | | | | | 10 | 30 | 30 | 30 | 40 | 40 | 40 | 440 |
| | A.M. Type 3 No. II | 1944 | | | | 10 | 20 | 20 | 30 | 70 | 80 | 90 | | 40 |
| Isomura Products | A.M. Type 3 No. II | 1945 | 40 | | | | | | | | | | | 360 |
| | A.M. Type 3 No. II | 1944 | | | | 10 | 15 | 25 | 30 | 50 | 60 | 60 | 80 | 280 |
| Ozaki Mfg. Co. | A.M. Type 3 No. II | 1944 | | | | | | | | | | | | 50 |
| | A.M. Type 3 No. II | 1945 | 50 | | | | | | | | | | | 150 |
| Saito Centrifugal Machinery Co. | A.M. Type 3 No. III | 1944 | | | | 50 | 25 | 25 | | | | | | 240 |
| | A.M. Type 3 No. II | 1944 | | | | | 10 | 20 | 30 | 20 | 30 | 50 | 60 | 250 |
| Aichi Dokei | A.M. Type 3 No. II | 1945 | 50 | | | | | | | | | | | 70 |
| | A.M. Type 3 No. II | 1944 | | | | | | | | | | | | 90 |
| Nisigata Yoki | A.M. Type 3 No. II | 1944 | | | | | | | | | | | | |
| | A.M. Type 3 No. II | 1945 | 50 | 50 | 70 | 80 | | | | | | | | |
| Toko Electric Co. | A.M. Type 3 No. II | 1944 | | | | | | | | | 15 | 25 | 30 | |
| | A.M. Type 3 No. II | 1945 | 30 | 20 | 20 | 20 | | | | | | | | |